Cottonwood Creek PALS Design Project

Cottonwood Creek, WA

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RCO 18-2089P

Prepared for

WALLA WALLA COUNTY CONSERVATION DISTRICT
ESTABLISHED 1941

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1.0 INTRODUCTION

This section provides background for the Cottonwood Creek Post-Assisted Log Structure (PALS) Project (Project) and introduces Project goals and objectives based on habitat limiting factors identified in the Snake River Salmon Recovery Plan for SE Washington (SRSRB 2011) and the Walla Walla County Conservation District (WWCCD). This report is provided to document the Project goals and objectives, existing conditions at the site, and proposed designs and cost estimates for the preliminary design. The report is organized as follows:

- Section 1.0: Introduction (this section)
- Section 2.0: Existing Conditions
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1.1 Project Background

The 1.5-mile-long Project reach is located along two sections of Cottonwood Creek approximately 1.5 miles upstream of the confluence with Yellowhawk Creek (Figure 1). The downstream site is downstream of Powerline Road and the upstream site is upstream of Powerline Road. In this reach of Cottonwood Creek, significant impacts including lack of riparian vegetation and woody debris, channel instability, and lack of surface flow in late spring and early summer reducing availability of habitat for salmonids. The Project design will include a series of PALS and beaver dam analogs (BDAs) and several larger engineered structures in conjunction with riparian plantings to improve instream habitat, increase fine sediment retention, and improve riparian conditions to improve conditions for salmonids through a combination of willing landowners and measurable design criteria and objectives.

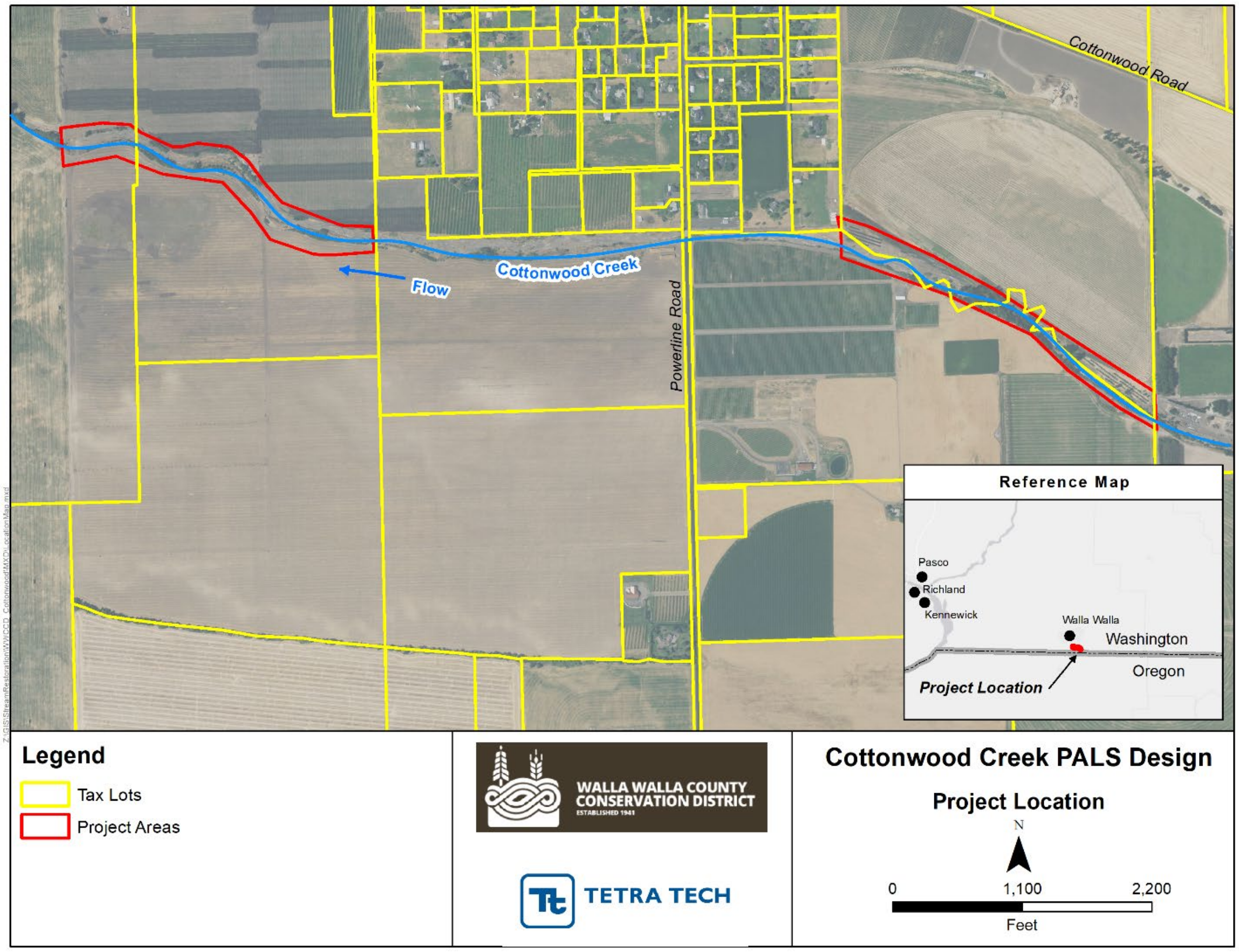


Figure 1-1. Cottonwood Creek PALS Design Project Location

1.2 Project Goals and Objectives

The Project design goal is to address limiting factors while maximizing habitat improvement. To meet this goal, the Project objectives include:

- Improvements to instream habitat quality and quantity
- Improving channel stability
- Improving riparian vegetation conditions

All objectives must be met in a way that includes feedback and approval from landowners along the reach. To address the Project objectives, quantifiable and repeatable metrics were identified to guide analyses and development of the Project design. Table 1-1 presents the metrics and demonstrates linkages between the Snake River Salmon Recovery Plan for SE Washington (SRSRB 2011) limiting factors and the identified metrics. Design criteria for project elements are intended to ensure that the engineering design meets project objectives and maintains compliance with applicable codes, standards, and established criteria. Table 1-2 below provides a summary of design criteria for project elements, including associated risks to infrastructure or failure to perform, and compensating analyses.

Table 1-1. Summary Snake River Salmon Recovery Plan for SE Washington (SRSRB 2011) Limiting Factors, Project Objectives, Project Metrics, and Evaluation Methods

Limiting Factor Category (SRSRB 2011)	Project Objectives	Metrics	Evaluation Methods
Habitat Quality and Quantity	Improve instream habitat quality and quantity	Primary Channel Length	Measure channel geometry from topographic survey
		Secondary Channel Length	Measure channel geometry from topographic survey and/or imagery (includes off-channel habitat)
		Bankfull Width	Measure channel geometry from survey cross-sections and/or hydraulic modeling results
		Bankfull Depth	Measure channel geometry from survey cross-sections and/or hydraulic modeling results
		Bankfull Cross-Sectional Area	Measure channel geometry from survey cross-sections and/or hydraulic modeling results
		Width/Depth Ratio	Measure channel geometry from survey cross-sections and/or hydraulic modeling results
		Gradient	Measure channel gradient from topographic survey
		Sinuosity	Measure from topographic survey
		Braided-Channel Ratio	Ratio of total channel length to the primary channel length (Friend and Sinha 1993)
		Channel Complexity Index	Sinuosity times the number of nodes utilized by valley distance (Brown 2002)
		Pool Frequency or Spacing	Count of number of pools per channel length (Montgomery et al. 1995)
		Relative Habitat Abundance	Measure of pool, riffle, run, and glide habitat percent of primary channel length
		Large Wood Counts	Tally the number of large wood pieces
		Abundance of Spawning and Rearing Habitat	Measure of abundance of spawning and rearing habitat for summer steelhead from hydraulic modeling and fish preference curves
Channel Stability	Improve channel stability	Sediment Size Distribution	Pebble counts of surface grains (Bunte and Abt 2001)
		Flow Competence	Calculate threshold of motion sediment size estimates with Shields equation (Shields 1936)
		Sediment Transport Rate	Calculate bed material transport rates
Water Temperature	Improve riparian vegetation conditions	Native riparian cover abundance, height, and condition	Utilize highest hit LiDAR returns to calculate canopy height in the riparian area, utilize OpenET data to calculate evapotranspiration rates

Table 1-2. Project Design Components, Design Criteria, Risk Assessments, and Compensating Analyses or Measures

Design Component	Design Criteria	Risk Assessment	Compensating Analyses or Measures
Riparian Vegetation and Wetlands	• Protect existing vegetation and snags • Establish wide riparian buffers • Plant for multispecies benefit (e.g., variety of vertical heights, understory cover, access points, species groupings) • Utilize increased side channel connectivity for riparian vegetation restoration	• Potential for low survival and ungulate browsing • Noxious weed infestations	• Install site appropriate native vegetation • Preserve and replant existing native vegetation where feasible • Hydrologic and hydraulic analyses • Technical specifications for plant handling, care, installation, and survival • Noxious weeds monitored and removed
In-channel Structures	• Increase habitat quantity and quality • Create channel roughness • Improve sediment sorting and retention • Key structures stable to the 100-year flow • Beaver Damn Analogs stable to the 2-year flow	• Risk to downstream infrastructure • Potential for deflection of flow towards channel banks resulting in increased bank erosion	• Structure stability calculations • Structure stability enhanced with pilings and ballasting alluvium • Shear stress estimates • Hydraulic analysis • Sediment transport analysis
Channel Form	• Where risk to infrastructure is low, channels to be designed to enable process and continued geomorphic change • Channel form and sediment routing to maintain aquatic communities • Minimization of excavation through use of pilot channels and allowing the stream to the do the work • Channel design to include single-thread low-flow channel to maintain fish passage	• Risk to infrastructure • Potential for unanticipated geomorphic and/or flow changes • Impacts to existing vegetation	• Hydrologic and hydraulic analyses to ensure delivery of flows • Velocity and shear stress calculations • Sediment transport modeling • Minimization of impacts to existing vegetation
Infrastructure	• Design capacities of existing bridges to be maintained • Maintain existing 100-year flood levels (i.e., no rise)	• Risk to infrastructure • Potential for deflection of flow towards channel banks resulting in increased erosion • Potential for unanticipated geomorphic and/or flow changes	• Hydrologic and hydraulic analyses • Velocity and shear stress calculations • Sediment transport modeling

2.0 EXISTING CONDITIONS

This section discusses the existing conditions in Cottonwood Creek at the Project site including historic conditions, site survey information, existing conditions hydrologic and hydraulic modeling, geomorphology, riparian conditions, and fisheries.

2.1 Historic Conditions

Until Euro-American settlers arrived, the streams and rivers of the Walla Walla Subbasin functioned more naturally with broad floodplains and healthy riparian areas. The Walla Walla River and its tributaries flow from the northeasterly facing slopes of the Blue Mountains toward the Columbia River (USFS 1941). Salmonids are assumed to have been able to exploit all suitable habitats below natural barriers. The streams and creeks that eventually flow into the Walla Walla River were probably very similar to one another. Cottonwood Creek and other stream banks in the lower elevations were likely heavily covered by cottonwood groves and woody vegetation. The presence of cottonwoods and conifers along the length of the creek would have assured a steady supply of woody debris to the system (SRSRB 2011).

Euro-American settlers brought disturbance with urban and agricultural development of the greater Walla Walla area. Many of the creeks, including Cottonwood Creek, were impacted by irrigation draws. As these small intermittent tributaries of Yellowhawk Creek went completely dry, they provided little to no value to salmonids in the Walla Walla basin (Nielson 1950). Significant impacts to naturally functioning stream processes include habitat encroachment, land-use modifications, altered hydrology, and altered floodplain connections which have impacted floodplain connection, sediment dynamics, and fish habitat.

2.2 Site Surveys

Field surveys were conducted for Cottonwood Creek from July 5 to 8, 2022. A total of 2,684 Global Positioning System (GPS) points were collected throughout the Project reach covering important site characteristics including channel bathymetry (edge of water, bankfull indicators, channel bottom, thalweg, habitat units) and topography (toe of slopes, road centerline, bridge abutments and centerlines, powerlines, and diversions). The points were collected using a Trimble R12 real-time kinetic (RTK) GPS with Global Navigation Satellite System (GLONASS) receivers. The survey control point base stations were established by collecting raw static GPS data for a minimum of four hours which were then submitted to the Online Positioning User Service (OPUS) for post-processing and conversion to the preferred coordinate system.

Two pebble counts were collected following the methodology of Bunte and Abt (2001). One pebble count was collected downstream of Powerline Road and one pebble count was collected upstream of Powerline Road. Sediment grain size distributions are shown in Section 2.4. Additionally, data was collected during the site visit using GPS enabled software of tablets and phones. This data included potential conceptual restoration ideas (i.e., structure placements, relic channel locations, side channel inlets and outlets), other relevant geomorphic information like large wood counts (Section 2.4), and riparian vegetation information (Section 2.5).

2.3 Hydrologic and Hydraulic Modeling

This section presents results of the existing conditions hydrologic and hydraulic modeling for the Project reach.

2.3.1 Hydrology

Cottonwood Creek just downstream of the Project area has a drainage area of 27 square miles and a mean annual precipitation of 40 inches (USGS 2022). Because the stream is ungaged, peak streamflows were evaluated using the USGS StreamStats application for a point just downstream of the downstream Project area (USGS 2022). Modeled flows are summarized in Table 2-1.

Table 2-1. StreamStats Peak Flows for Cottonwood Creek at Project Site

Recurrence Interval (years)	StreamStats Flow (cfs)
2	504
5	858
10	1,150
25	1,590
50	2,000
100	2,440

2.3.2 Hydraulic Modeling

For the existing conditions modeling, the primary tool for conducting the hydraulic analysis was a comprehensive 2-D hydraulic model using Hydraulic Engineering Center-River Analysis System (HEC-RAS) 2D, which is a 2-D model developed by the U.S. Army Corps of Engineers (USACE) for use in computing velocity, flow depth, shear stress, and other hydraulic characteristics such as sediment transport in riverine systems. This model was used to evaluate the baseline conditions of the upstream and downstream Project reaches, assist in developing the conceptual design alternatives for the Project reaches, and support future permitting review.

The existing conditions modeling terrain was generated using AutoCAD Civil 3D (Civil 3D) 2022 from topographic survey data (Section 2.2) combined with LiDAR survey data from 2018. Comparisons of GPS points versus LiDAR were made at fixed areas such as paved roads and bridges and indicated no need to make any adjustments to the LiDAR surface.

Land use for the model was based on aerial imagery and knowledge gained from field surveys. The land use was delineated and assigned a Manning's n roughness value. Roughness values generally follow recommendations provided by Chow (1959) as well as professional experience and judgement. Based on the aerial map, a land cover file was generated for Manning's roughness with values ranging from 0.02 to 0.1, representing road surfaces to developed areas (Table 2-2).

Table 2-2. Manning's Roughness Values by Land Use

Land Use/Land Cover	Manning's n Value
Channel	0.04
Floodplain	0.05
Agriculture	0.035 – 0.05
Road	0.02
Developed	0.10
Forested	0.08
Scrub	0.06

Current conditions in the existing channel in the upstream section are incised with high velocities and shear stress in the channel. Bankfull indicators were collected during the site survey and was compared to the results of the existing conditions modeling and appear consistent with the 2-Year inundation boundary in the downstream area and a little narrower in the upstream area. Floodplain inundation extents are limited below the 25-year flood recurrence with minimal off-channel habitat available in the downstream area (Figure 2-1). Existing conditions modeling indicates inundation extents of 5.8 acres, 11.1 acres, 12.6 acres, and 15.2 acres for the 2-, 10-, 25-, and 100-year flood recurrence events, respectively in the upstream area. Existing conditions modeling indicates inundation extents of 5.9 acres, 11.4 acres, 22.6 acres, and 39.2 acres for the 2-, 10-, 25-, and 100-year flood recurrence events, respectively in the downstream area. Detailed results of the hydraulic modeling for the existing conditions are provided in Appendix C.

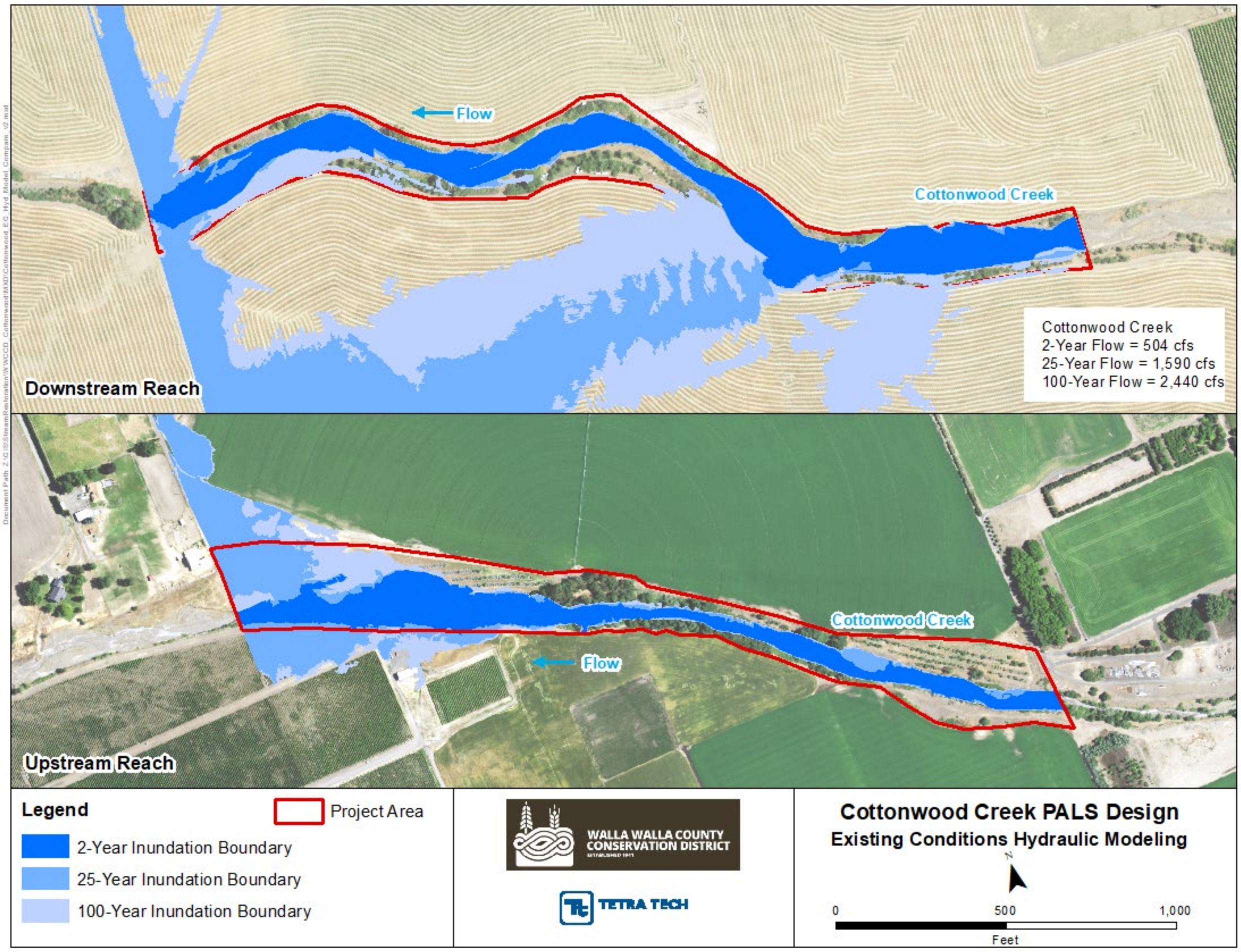


Figure 2-1. Existing Conditions Hydraulic Modeling Results

Sediment transport modeling was also analyzed for the existing conditions utilizing HEC-RAS. Sediment transport was modeled at the 2-year flood recurrence interval (Figure 2-2). The existing sediment transport model results are confirmed by observations made in the field. Bank erosion was noted in places along both banks in the downstream and upstream Project areas. Deposition was noted primarily upstream of Powerline Road.

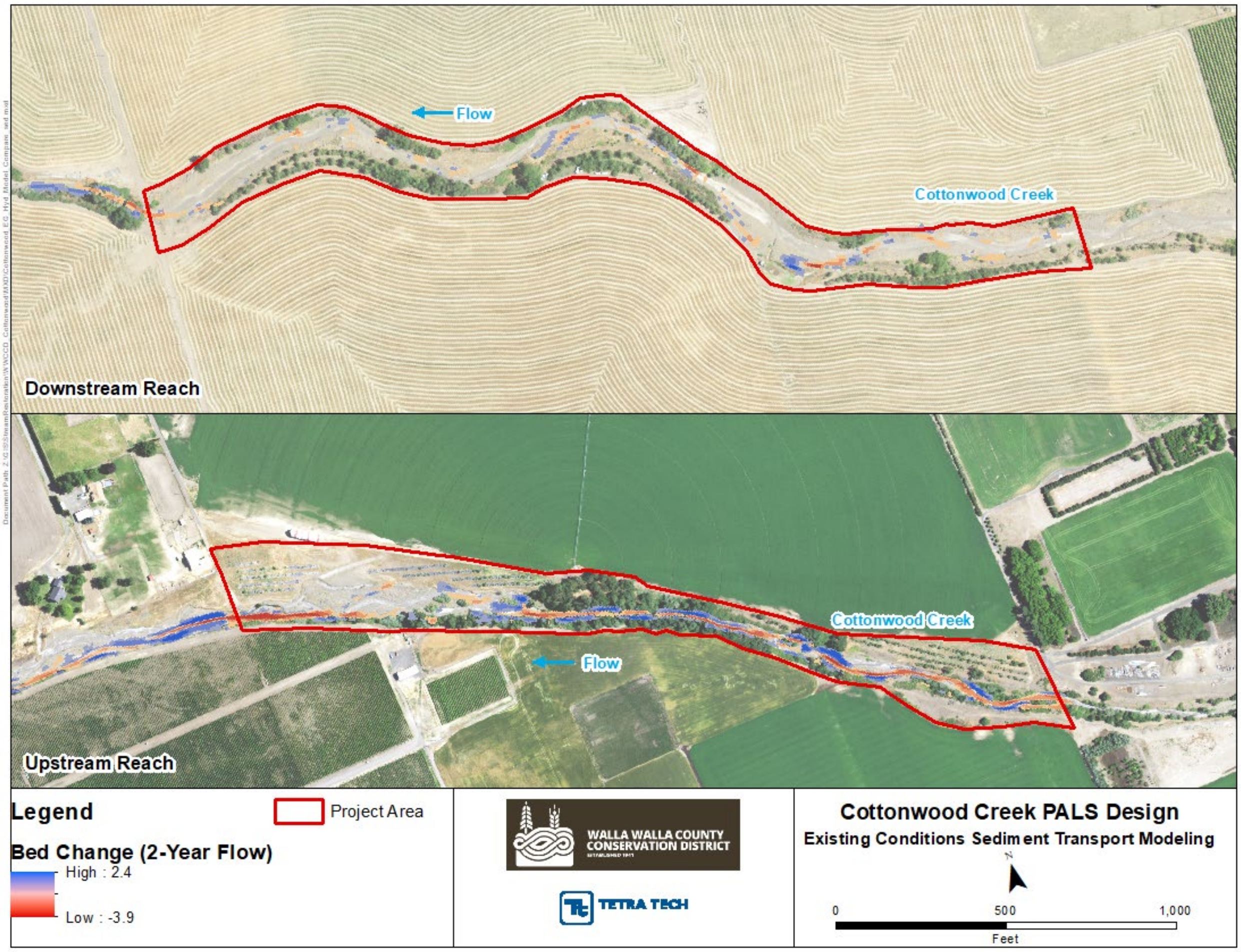


Figure 2-2. Existing 2-Year Flood Recurrence Sediment Transport Modeling Results

2.4 Geomorphology

The landscape of the Cottonwood Creek drainage and the Walla Walla valley has been shaped by geologic forces including basalt bedrock, tectonic stresses including faulting and folding, glacial outburst floods during the ice age, wind-blown silts, and the re-working of surface deposits by streams and rivers (CTUIR 2017). The historic landscape would have comprised numerous pool-riffle complexes and abundant off-channel habitat in the lower drainage (NPCC 2005). The natural distributary system resulting from the alluvial fan created by streams exiting the Blue Mountains and rapidly losing gradient would naturally have flooded during high flows. This natural distribution of water and sediment across the alluvial fan would have created floodplain channels, backwaters, elevated pond areas, abundant large wood supply for large wood structures in the channel, and bountiful habitat for beavers in wetland complexes (CTUIR 2017). As discussed in Section 2.1, the Euro-American development and settlement of the Mill Creek drainage has reduced ecological functionality and reduced available salmonid habitat.

Currently, Cottonwood Creek in the Project area is defined by an incised channel with sparse riparian cover (see Section 2.5), minimal large wood to available to provide in-channel habitat complexity for salmonids, degraded bank conditions, and a channel that goes dry early in the summer in the downstream reach. The channel is steep and confined in the upstream section of the upstream Project reach before losing gradient and depositing materials across a broader channel width just upstream of Powerline Road. This creates an aggradational reach where materials are deposited, and over-bank flooding is frequent.

Downstream of Powerline Road, the gradient is fairly uniform and the reach is more transitional then depositional. The channel is incised and perched above the floodplain. At high flows, the over-bank flooding is frequent due to the low elevation of the surrounding floodplain. This also explains the reach going dry during the summer months because the water table is generally lower than the channel bottom in the reach.

Two pebble counts were collected in the Project reaches. One was collected downstream of the Powerline Road bridge and one was collected upstream of the bridge. The results of the pebble counts show that the sediment particle size is similar throughout the Project with the D_{50} being 44.2 millimeters (mm) downstream of the bridge and 44.2 mm upstream of the bridge (Figure 2-3). Most of the sediment in the channel is gravels and cobbles with minimal sands.

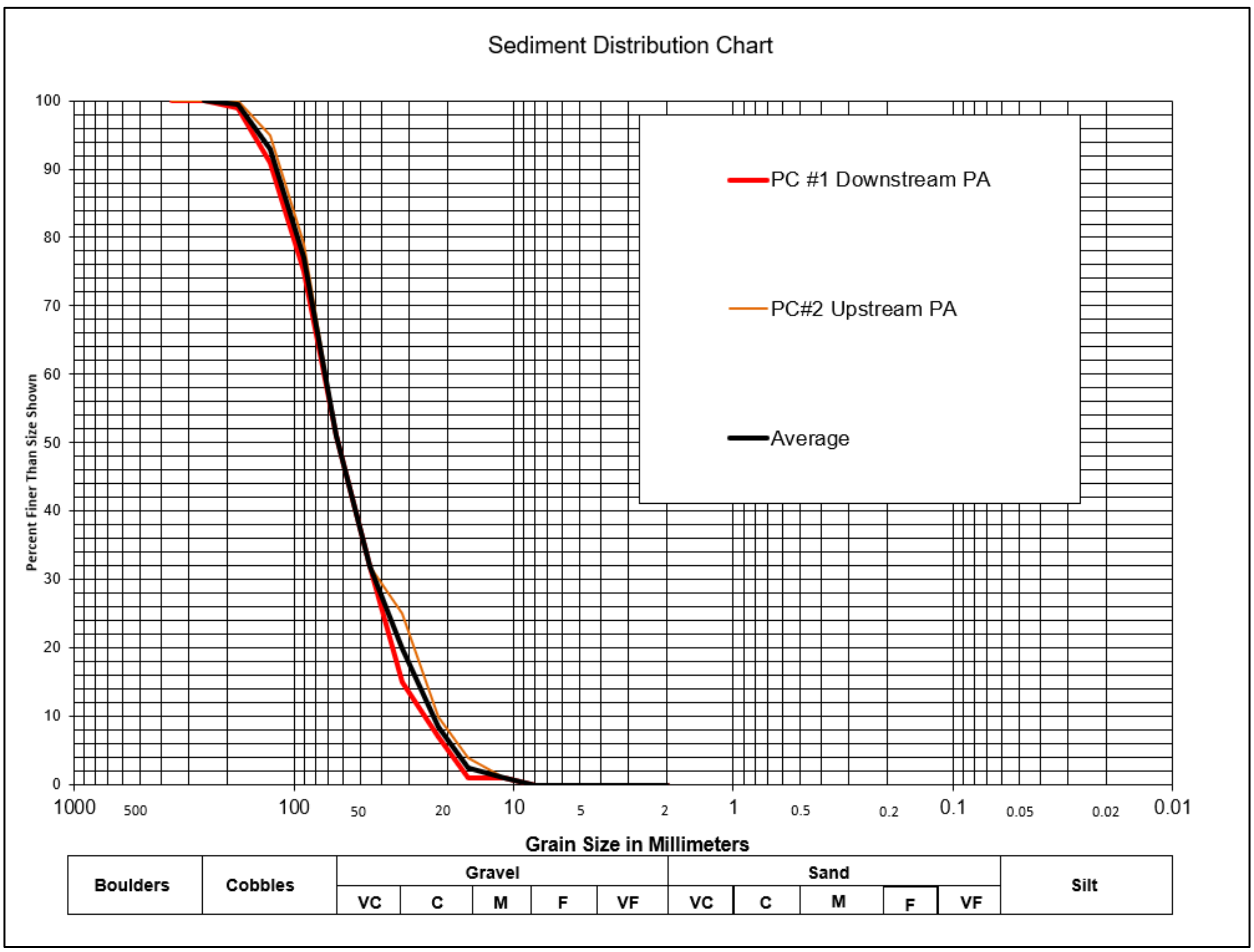


Figure 2-3. Pebble Count Data for the Project Reaches

Table 2-3 summarizes existing conditions geomorphic metrics for the upstream reach and Table 2-4 summarizes existing conditions geomorphic metrics for the downstream reach. A relative elevation model (REM) was completed for the existing conditions surface to provide context for potential design elements. To calculate the relative elevation of the ground surface above the channel bottom, the baseline elevation was detrended to follow the channel bottom of the creek. In the model, elevations trend higher as one moves away from the river bottom, showing the “relative” height above the channel bottom.

Table 2-3. Geomorphic Metrics for the Upstream Reach

Reach Characteristics		
Floodplain Inundation (acres)	2-Year Flow	5.8 acres
	10-Year Flow	11.1 acres
	100-Year Flow	15.2 acres
Primary Channel Length (feet)	3,393 feet	
Secondary Channel Length (feet)	1,016 feet	
Bankfull Width (feet)	48 feet	
Bankfull Depth (feet)	1.29 feet	
Bankfull Cross-Sectional Area (square feet)	62 square feet	
Width/Depth Ratio	37.2	
Gradient (percent)	1.54 %	
Sinuosity	1.09	
Braided-Channel Ratio	1.30	
Channel Complexity Index	16.5	
Pools per Mile	11	
Relative Habitat Abundance	Pool (percent)	4 %
	Riffle (percent)	59 %
	Run (percent)	27 %
	Glide (percent)	10 %
Large Wood	34 pieces per mile	
	30 cubic yards per mile	
Abundance of Steelhead Habitat at Bankfull Flow (acres)	Spawning	1.57 acres
	Rearing	3.35 acres
Average Canopy Height (feet)	7.5 feet	
Evapotranspiration (inches per year)	Average	31.0 inches
	Range	5.22 inches

Relative Elevation Model and Photos

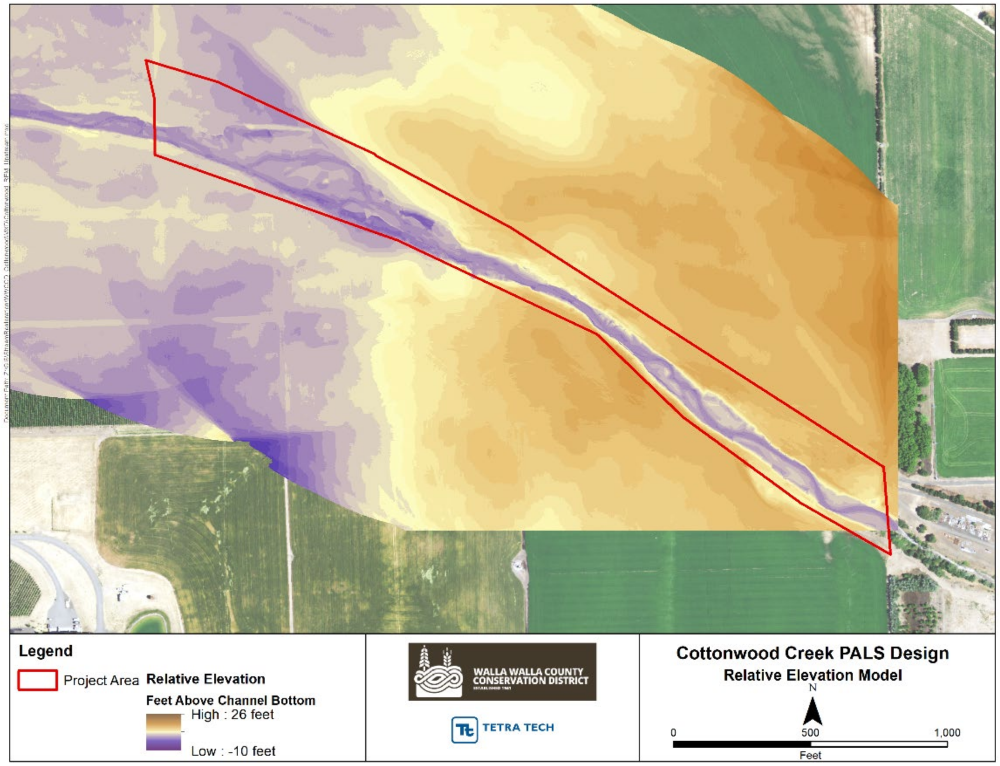
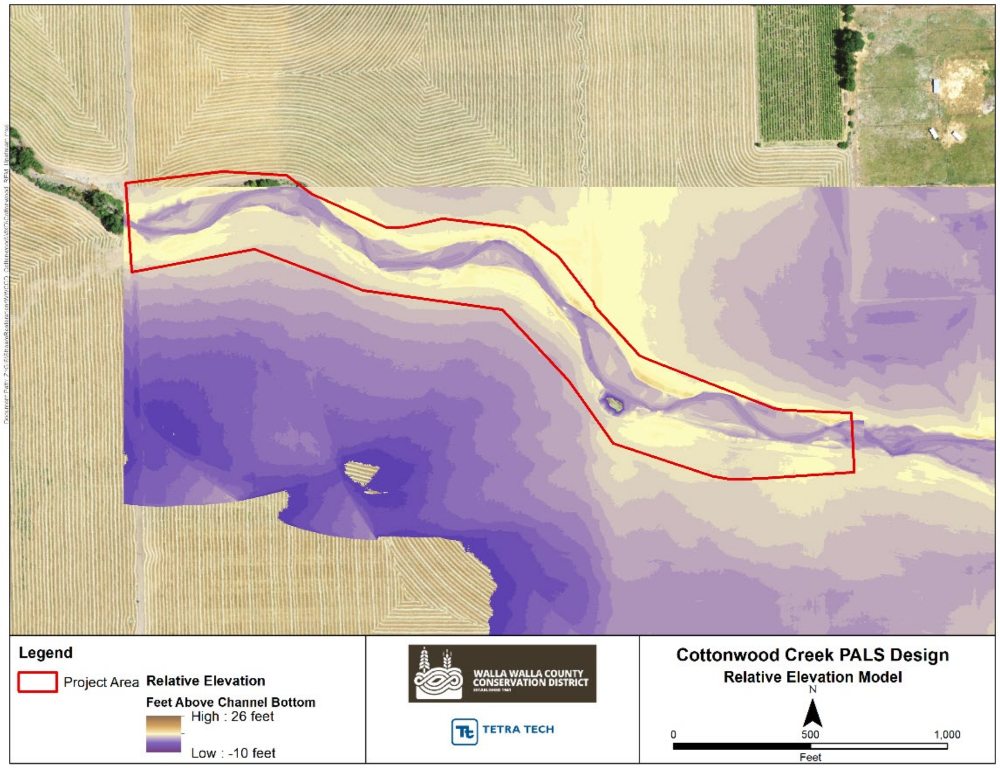


Table 2-4. Geomorphic Metrics for the Downstream Reach

Reach Characteristics		
Floodplain Inundation (acres)	2-Year Flow	5.9 acres
	10-Year Flow	11.4 acres
	100-Year Flow	39.2 acres
Primary Channel Length (feet)	3,400 feet	
Secondary Channel Length (feet)	0 feet	
Bankfull Width (feet)	60 feet	
Bankfull Depth (feet)	1.50 feet	
Bankfull Cross-Sectional Area (square feet)	90 square feet	
Width/Depth Ratio	40.0	
Gradient (percent)	1.05 %	
Sinuosity	1.21	
Braided-Channel Ratio	1.00	
Channel Complexity Index	2.27	
Pools per Mile	8	
Relative Habitat Abundance [1/]	Pool (percent)	N/A
	Riffle (percent)	N/A
	Run (percent)	N/A
	Glide (percent)	N/A
Large Wood	5 pieces per mile	
	2 cubic yards per mile	
Abundance of Steelhead Habitat at Bankfull Flow (acres)	Spawning	1.83 acres
	Rearing	3.94 acres
Average Canopy Height (feet)	4.3 feet	
Evapotranspiration (inches per year)	Average	30.0 inches
	Range	7.67 inches

Relative Elevation Model and Photos



1/ Channel was dry during survey, no habitat units were verified except for pools where water was present.

The reference reach identified in the field and via desktop analyses includes dense riparian canopy in the steepest stretch of the upstream project area followed by a series of small debris structures downstream where the slope decreases. These small debris structures have allowed the formation of small, vegetated islands that are promoting improved sediment transport and improved riparian conditions (Figure 2-4). Proposed design elements should seek to mimic this naturally formed topography to improve riparian conditions, salmonid habitat, and channel stability.

Figure 2-4. Examples of Small Wood Structures and Vegetated Islands in the Downstream Section of the Reference Reach

2.5 Riparian Conditions

As part of the greater Walla Walla River drainage, historic vegetation in the Cottonwood Creek drainage looked much the same, with timber and brush mixed with forbs and grass in the mountains, bunch grasses in the middle elevations, and wild rye and sagebrush in the lower elevation valleys (USFS 1941).

With the arrival of early Euro-American settlers in the 1800's, the landscape was altered for use in agriculture including wheat, corn, onion, melons, and other crops and for the introduction of livestock (SRSRB 2011). Timber harvesting also began in earnest in the nearby Blue Mountains to supply the urban development and expansion of the railroads (CTUIR 2017). Conversion of native habitats has altered much of the riparian habitat within the floodplain (NPCC 2005) and the subsequent extirpation of beavers and removal of wetlands and ponds from urbanization has further degraded riparian conditions to this day.

During the site surveys, riparian vegetation was documented. While sections of the creek are more shaded, most of the Cottonwood Creek riparian area is open, with about 50 percent canopy cover on the banks. The understory is weedy and is dominated by Himalayan blackberry (*Rubus armeniacus*). Other woody vegetation present includes black cottonwood (*Populus balsamifera*), black locust (*Robinia pseudoacacia*), elderberry (*Sambucus nigra*), smooth sumac (*Rhus glabra*), and coyote willow (*Salix exigua*). Herbaceous cover consists of poison hemlock (*Conium maculatum*), bull thistle (*Cirsium vulgare*), star thistle (*Centaurea solstitialis*), and rush skeletonweed (*Chondrilla juncea*). Average canopy height in the upper project reach is 7.5 feet with a maximum of 80 feet and average canopy height in the lower project reach is 4.3 feet with a maximum of 53 feet.

Another measure of riparian health is evapotranspiration (ET) rates. OpenET (Windward Fund, Inc. 2022) utilizes publicly available data to provide satellite-based estimates of ET across the western United States. The website provides daily, monthly, and annual satellite-based ET estimates. Higher ET rates are generally associated with riparian plant health where plants are photosynthesizing and open water is available. Lower ET rates are associated with few plants or no open water to evaporate. Healthy riparian areas with high ET rates are also more resilient to drought and other stressors (Fairfax and Small 2018). Cumulative ET rates were downloaded and compared for the downstream reach, upstream reach, and the reference reach for 2017 through 2021 (Figure 2-5).

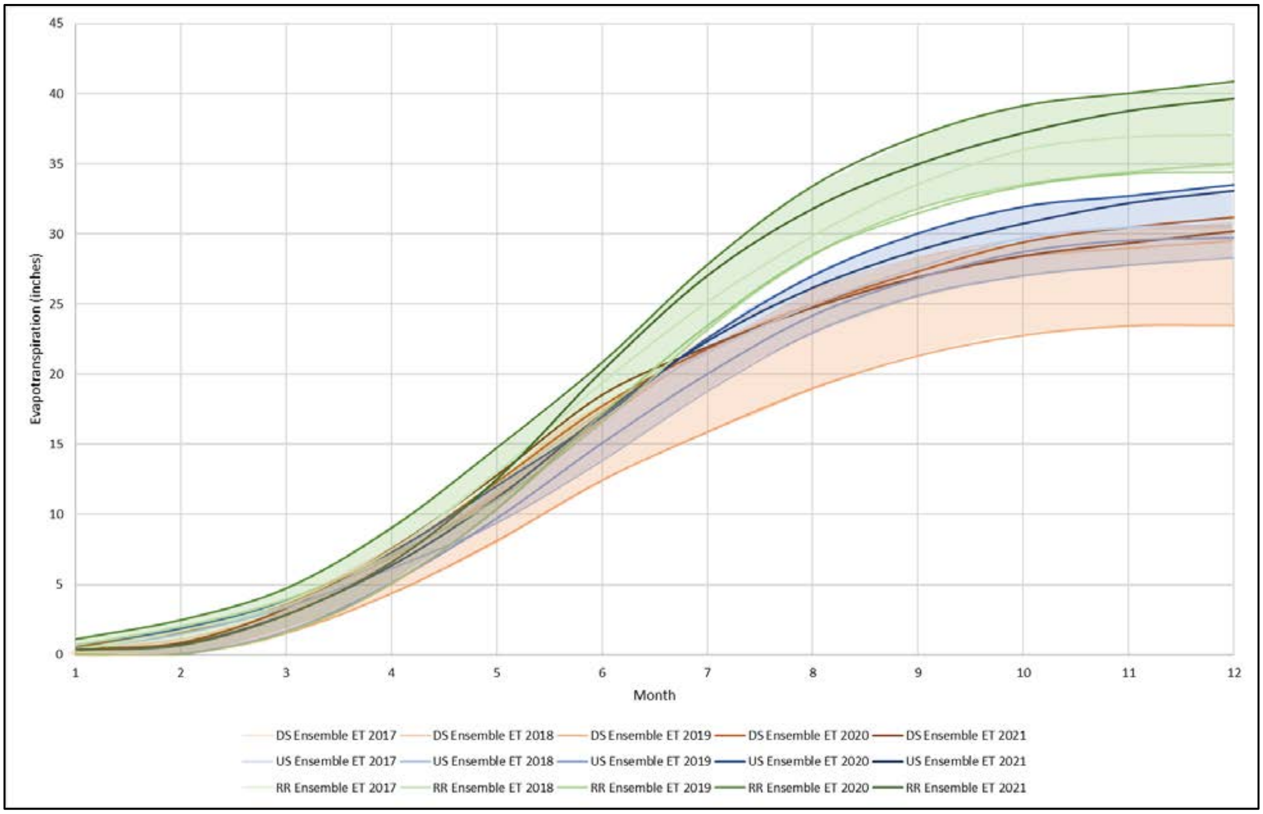


Figure 2-5. Cumulative ET Rates for the Downstream Reach, Upstream Reach, and Reference Reach

The ET rates for the downstream reach show an average ET rate of 30.0 inches per year and a range of 7.67 inches. For the upstream reach, an average ET rate of 31.0 inches and a range of 5.22 inches. For the reference reach, an average ET rate of 37.4 inches and a range of 6.44 inches. The depressed rate of ET in the downstream reach correlates with the field observations of decreased riparian health and the increased rate of ET in the upstream reach and the reference reach correlate with the field observations of generally healthier riparian function. The target for the riparian conditions would be to improve the downstream reach ET rates to more closely align with the rates observed in the upstream reach or in the reference reach.

2.6 Fisheries

The primary fish species found in Cottonwood Creek is Endangered Species Act (ESA)-listed Middle Columbia River Distinct Population Segment (DPS) steelhead (*Oncorhynchus mykiss*). Other species include rainbow and redband trout (StreamNet 2022). Bull trout are not confirmed to exist in Cottonwood Creek (SRSRB 2011). Figure 2-6 provides fish use and timing of life stages for the focal fish species present in Cottonwood Creek as discussed in the Snake River Salmon Recovery Plan.

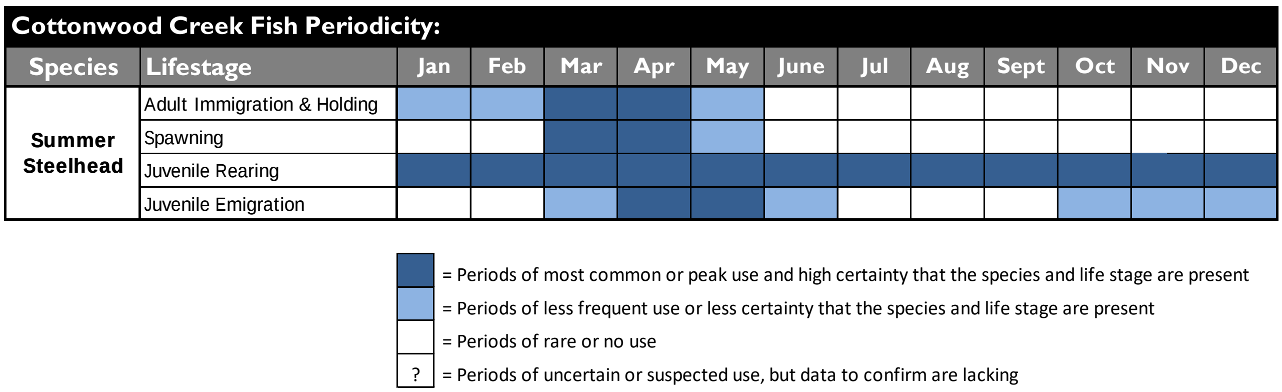


Figure 2-6. Fish Periodicity Chart for Aquatic Species in Cottonwood Creek

Middle Columbia River DPS steelhead are currently the only anadromous salmonid found in the Cottonwood Creek watershed. Cottonwood Creek is an important part of the Walla Walla subbasin and would be a component for recovery of the Middle Columbia River DPS steelhead. Steelhead are present in the Cottonwood Creek drainage year-round and typically use the Project reach for spawning and rearing (SRSRB 2011 and StreamNet 2022). Limiting factors for salmonids in the Walla Walla River subbasin are identified in WSCC (2001), NPCC (2005), and SRSRB (2011). Table 2-5 below summarizes the limiting factors identified in these studies.

Table 2-5. Limiting Factors for Productivity of Salmonids in Cottonwood Creek in the Project Reach

Limiting Factor Category	Limiting Factor	Limiting Factor Rating
In-Channel Characteristics	Passage/Entrainment	Moderately Limiting
	Channel Substrate	Moderately Limiting
	Large Wood	Partially Limiting
	Pool Frequency/Quality	Partially Limiting
	Pool Depth	Partially Limiting
	Sediment	Moderately Limiting
	Water Quality – Temperature	Highly Limiting
	Water Quantity – Flows	Highly Limiting
Riparian/Floodplain	Riparian Condition	Moderately Limiting
	Streambank Condition	Moderately Limiting
	Channel Stability	Moderately Limiting
	Off-Channel Habitat	Partially Limiting

3.0 PROPOSED SITE CONDITIONS, DESIGNS, AND ANALYSES

This section presents engineering analyses performed for the preliminary design. This includes a discussion of the preliminary design alternatives, the preferred alternative design and design considerations, proposed conditions hydraulic modeling results and sediment transport, and large wood stability.

3.1 Preliminary Design Alternatives

The following section describe the alternatives analysis for the preliminary design.

3.1.1 Previous Designs

A previous design was provided to Tetra Tech by WWCCD at project initiation. This design was reviewed and discussed with WWCCD to identify potential changes to the design. The original design called for the installation of 23 PALS and BDA structures and riparian plantings downstream of the structures along with 7 large wood structures that featured logs anchored with chain and pins to ballast boulders (Appendix A).

3.1.2 Alternative 1

Tetra Tech identified the significant changes to the bathymetry and topography in the Project reach following the site surveys (Section 2.2). With the analysis of the updated surface and other geomorphic indicators and discussions with WWCCD, the previous design was modified to an alternative design that closely matches reference reach conditions identified in the upstream section of the Project (Section 2.4), and maximized the restoration goals and objectives of improving riparian conditions, improving channel stability, and improving instream habitat quality and quantity. This alternative included 20 PALS and BDAs and 9 bank habitat structures in the downstream Project area and 14 PALS and BDAs and 10 bank habitat structures in the upstream Project area. This alternative also included riparian plantings associated with the PALS and BDA structures as well as with the bank habitat structures.

3.1.3 Alternative 2

Based on modeling results and discussions with WWCCD, Alternative 1 was further modified to meet landowner goals of not increasing flooding inundation in the adjacent agricultural fields in Alternative 2. This alternative features 20 PALS and BDAs and 9 bank habitat structures in the downstream Project area and 14 PALS and BDAs and 9 bank habitat structures in the upstream Project area. However, to account for flooding inundation protection, a berm was proposed in the downstream Project area to protect adjacent fields from increased inundation. This alternative also included riparian plantings associated with the PALS and BDA structures as well as with the bank habitat structures.

3.1.4 Alternatives Analysis

Table 3-1 below presents the decision matrix for the previous design and the Project alternatives. The decision matrix identifies the Project objectives and how the alternatives meet the needs of the objectives.

Table 3-1. Alternatives Decision Matrix

Project Objective	Previous Design	Alternative 1	Alternative 2
Improve Instream Habitat Quality and Quantity			
Improve Channel Stability			
Improve Riparian Conditions			

= Exceedingly meets objective

= Adequately meets objective

= Minimally meets objective

The provided previous design would adequately meet the objectives of improving channel stability and improving riparian conditions. However, this design was based on topographic and bathymetric data that was outdated and included structures with bolts and chains for anchors which does not improve habitat quality and quantity. If structures are moved or the wood material decays in the structure, habitat quality is degraded with the leftover non-natural materials that were used for anchoring.

Alternative 1 exceedingly meets the objectives of improving instream habitat quality and quantity and improving riparian conditions. The alternative includes the installation of habitat structures like PALS and BDAs and bank habitat features that will improve conditions in the channel. Plantings associated with the installation of these structures would further improve habitat quality while improving riparian conditions. However, because of the increased roughness in the channel, the alternative does not improve channel stability and increases flooding inundation to adjacent properties.

Alternative 2 exceedingly meets all objectives. The installation of the habitat structures (i.e., PALS and BDAs and bank habitat features) along with riparian plantings will improve habitat quality and quantity. Furthermore, the installation of the berm on the left bank in the downstream Project area would improve channel stability and reduce flooding inundation to adjacent properties.

3.2 Preferred Preliminary Alternative Design

Based on the reference reach conditions, the previous design that was provided to Tetra Tech, and the described alternatives analysis, Alternative 2 was chosen as the preferred preliminary design was chosen. The design proposes utilizing PALS and BDAs in concert with riparian plantings and large wood structures to promote development of islands of vegetation and restoration of healthy riparian areas. As described in Section 2.4, the reference reach includes dense riparian canopy in the steepest stretch of the upstream project area followed by a series of small debris structures downstream where the slope decreases. These small debris structures have allowed the formation of small, vegetated islands that are promoting improved sediment transport and improved riparian conditions. The proposed design elements seek to mimic this naturally formed topography to improve riparian conditions, salmonid habitat, and channel stability.

The upstream section of the Project will include PALS and BDAs to mimic the reference reach along with habitat bank structures to promote channel stability and provide opportunity for the riparian plantings to mature. Within the reference reach, minimal design elements will be included. Upstream of the reference reach, more design elements will be implemented to further promote riparian health, channel stability, and sediment sorting.

The downstream section of the Project will include PALS and BDAs and bank habitat structures throughout to meet project objectives of improved riparian health, improved salmonid habitat, and improved bank stability. The placement of PALS and BDAs and riparian plantings are intended to also mimic the reference reach described above in the upstream project area. The PALS and BDAs are strategically placed to reduce bank erosion, protect existing riparian areas, and promote channel complexity. The bank habitat structures are also strategically placed to protect existing riparian areas and reduce bank instability.

3.3 Preliminary Design Drawings

Full detailed design drawings are provided in Appendix B. Figure 3-1 below provides an overview of proposed design elements for the project area.

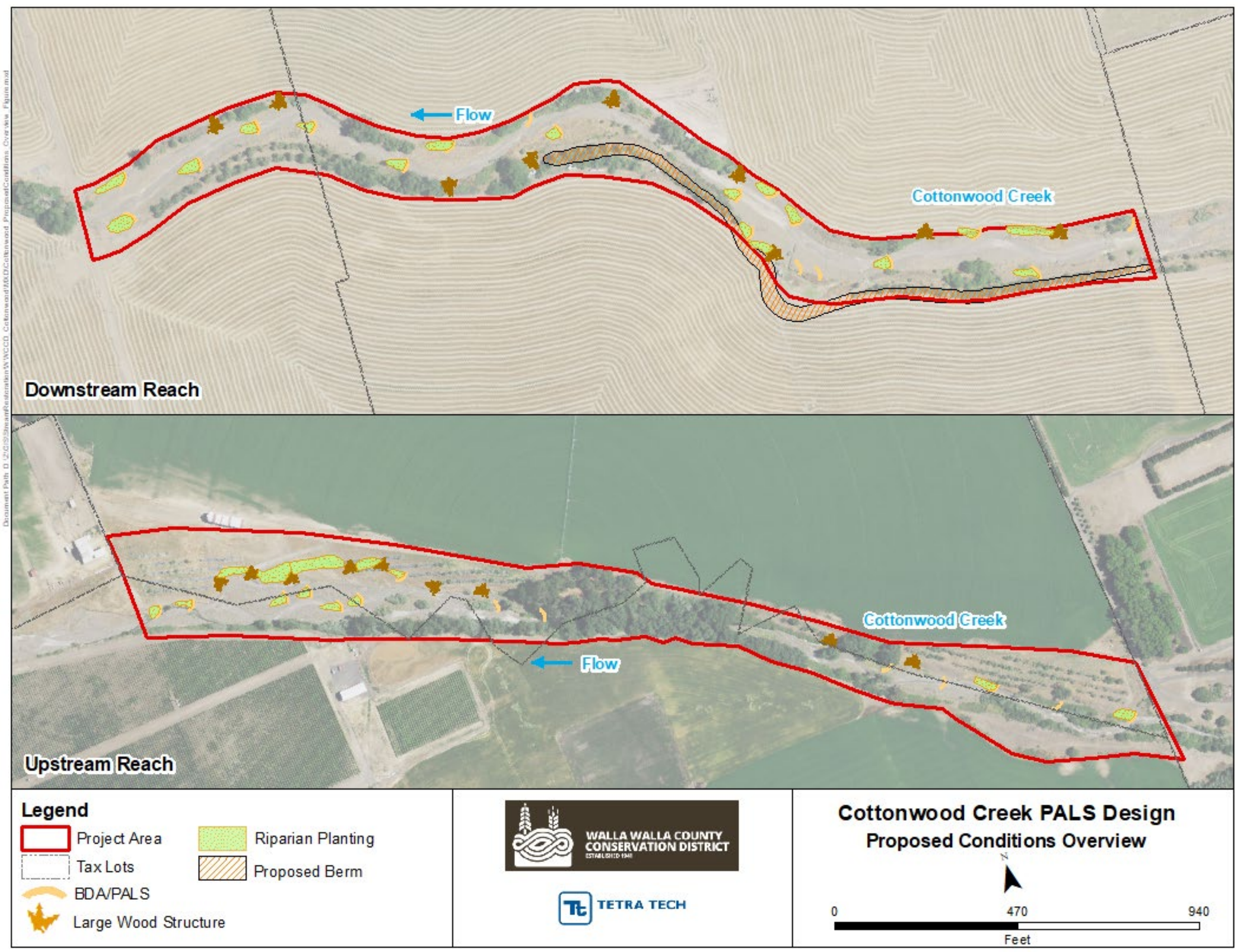


Figure 3-1. Overview of Preliminary Design Elements

3.4 Design Considerations and Preliminary Analyses

The following sections describe the design considerations and preliminary engineering analyses for the preliminary design for the Project. An overview of the potential risks identified for the engineering designs for preliminary design elements and the analyses or measures to address those risks is provided in Table 3-2 below.

Table 3-2. Risk Assessments and Compensating Analyses or Measures

Consideration	Risk Assessment	Analyses or Measures
Flooding	• Potential for flood inundation to adjacent infrastructure including residents and agricultural development	• Hydrologic and hydraulic analyses of existing and proposed conditions (Section 2.3.1, 2.3.2, and 3.4.1, and Appendix C)
Safety	• Potential for impacts to bridges downstream of project reach	• Large wood structure stability calculations, with stability to the 2-year or 100-year recurrence interval depending on structure type (Section 3.4.2, Appendix C) • Sediment transport analyses of existing and proposed conditions (Section 2.3.2, 3.4.1.2, and Appendix C)
Project Stability	• Large wood structures	• Structure stability calculations, with stability to the 2-year or 100-year recurrence interval depending on structure type (Section 3.4.2) • Hydraulic analyses (Section 2.3.2, 3.4.1) • Shear stress calculations, vertical stability of riverbed, and scour (Sections 3.4.1, Appendix C)

Consideration of flooding risks in the downstream Project area resulted in the need for the addition of a berm feature to protect private property from increased flooding inundation. The increased roughness in the channel for salmonid habitat results in an increase in flooding on the left and right banks of the creek with existing bank features. Therefore, to meet the design constraint of limiting increases in flooding, the design also includes a berm on the left bank to protect the adjacent agricultural lands from increased flooding potential. Results of the proposed hydraulic modeling showing the reduction in flooding are discussed in Section 3.4.1.1 below.

3.4.1 Hydraulic Modeling

Hydraulic modeling for the proposed conditions shown on Figure 3-1 was performed to evaluate the selected design alternative. The updated 2D HECRAS model coupled with Civil 3D 2022 were the primary software applications. The existing surface was modified to include the proposed large wood structures. New inputs included additional Manning's n values of 0.075 for large wood structures and 0.055 for proposed riparian planting areas. Results of the modeling were utilized to evaluate the stability of the proposed structures.

3.4.1.1 Proposed Conditions Hydraulic Modeling Results

Figure 3-2 and Figure 3-3 presents the inundation extents for the existing and proposed conditions for both the upstream and downstream Project areas. Table 3-3 presents a summary of inundation extents compared to the existing conditions. For the proposed design, inundation extents are maintained at the 5-year event and reduced at the 10-year, 25-year, and 100-year events with the inclusion of a flood protection berm. Detailed results of the hydraulic modeling for the proposed conditions are provided in Appendix C.

Table 3-3. Inundation Comparison Between Existing and Proposed Modeling

Recurrence Interval Event (year)	Upstream		Downstream	
	Existing Inundation (acres)	Proposed Inundation (acres)	Existing Inundation (acres)	Proposed Inundation (acres)
2-Year	5.8	5.7	5.9	5.9
10-Year	11.1	11.1	11.4	9.7
25-Year	12.6	12.9	22.6	14.0
100-Year	15.2	15.6	39.2	25.7

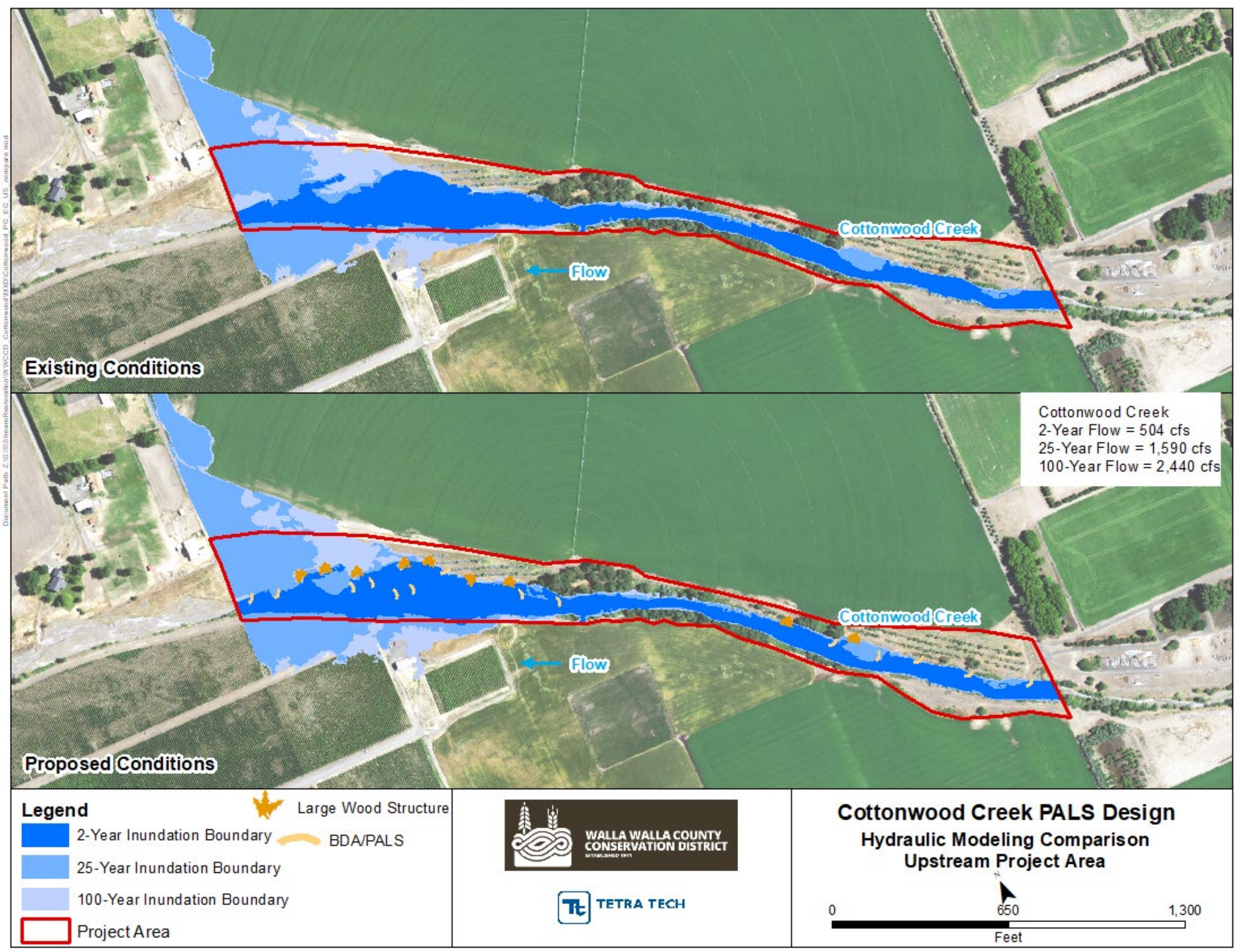


Figure 3-2. Comparison of Hydraulic Modeling Results for the Upstream Project Area

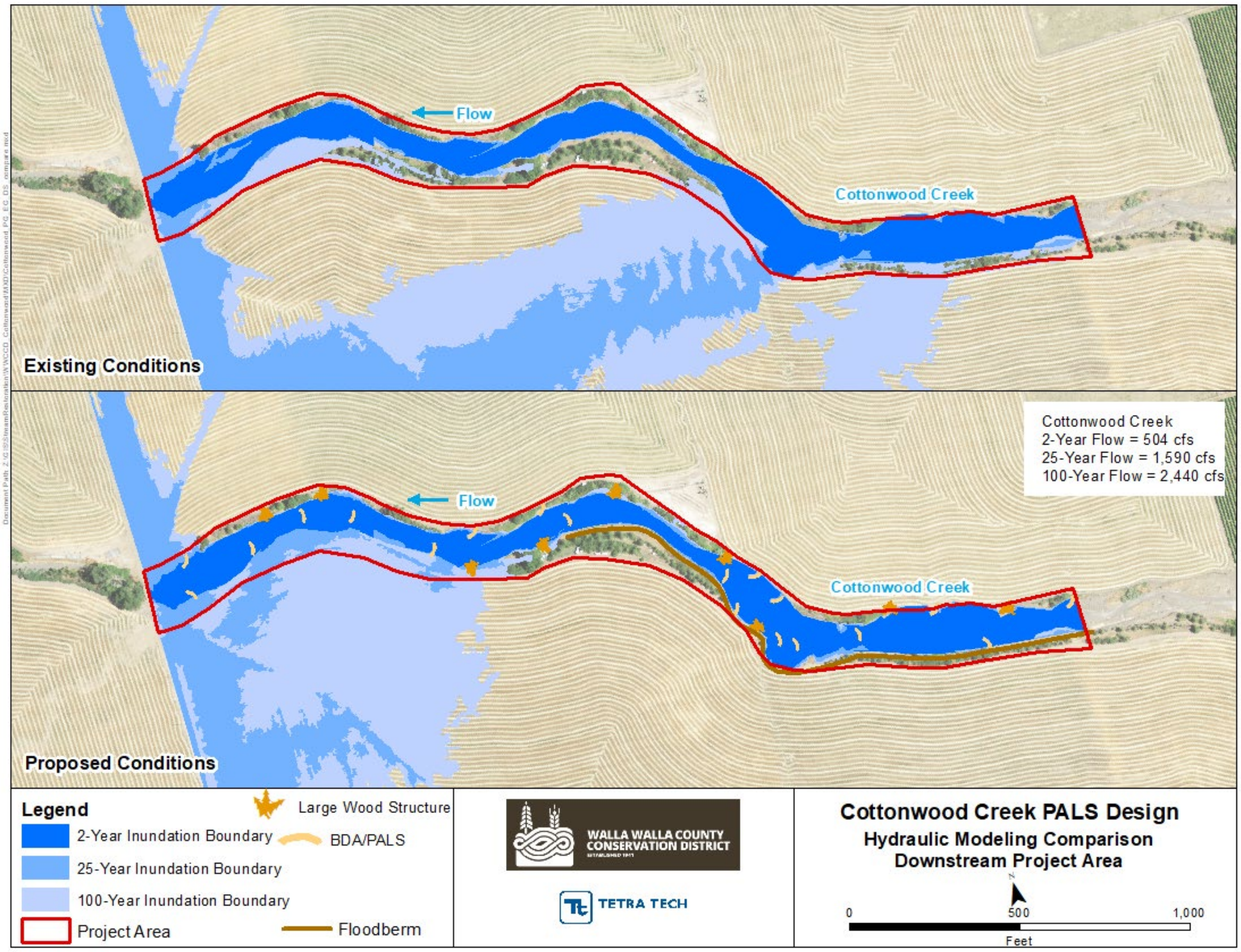


Figure 3-3. Comparison of Hydraulic Modeling Results for the Downstream Project Area

3.4.1.2 Proposed Conditions Sediment Transport

Results of the proposed conditions sediment transport modeling for the 2-year flow are provided in Figure 3-4. Overall deposition and erosion locations appear consistent with the existing conditions, with slight increases in deposition behind large wood structure locations.

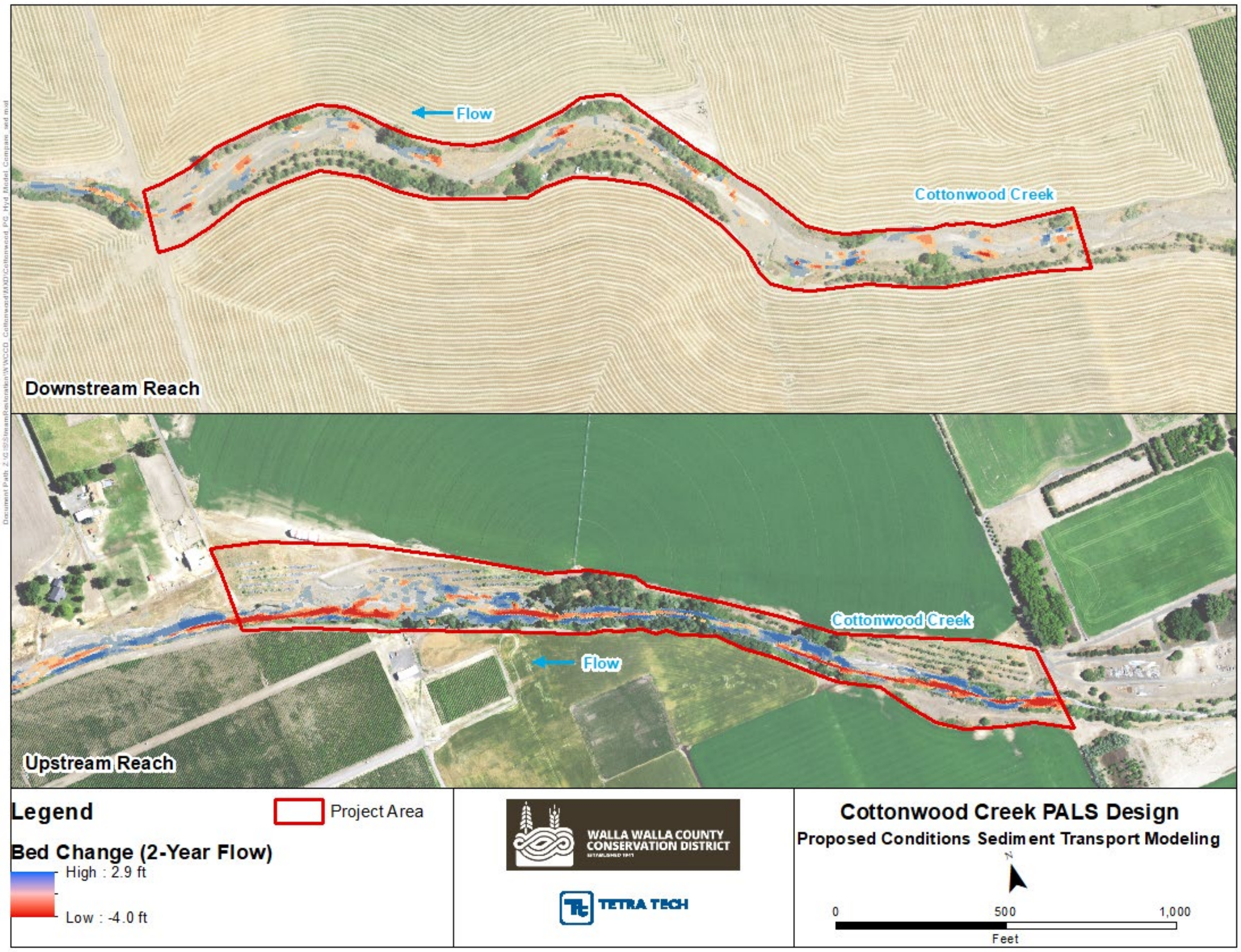


Figure 3-4. Proposed 2-Year Flood Recurrence Sediment Transport Modeling Results

3.4.2 Large Wood Structure Stability

A total of 50 in-stream structures are proposed for the project. The in-lines structures are described in Section 3.2 and include the bank habitat, bank attached PALS, and centerline BDA structures.

All proposed in-stream structures have been designed to generally follow placement strategies and size requirements outlined in the Stream Habitat Restoration Guidelines (WSAHGP 2012), and the National Large Wood Manual – Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Functions, and Structure (USBR and USACE 2016). All structures have been designed for specific functions within the riverine ecosystem. The structures have been positioned throughout the project area to assist in promoting improved sediment transport and improved riparian conditions by allowing riparian planting to mature.

The buoyancy, sliding, post rotation failure, and post breakage calculation results are based on the standard force balance approach derived from D'Aoust and Millar (2000) coupled with the USBR and USACE (2016) National Large Wood Manual and are provided Appendix C. Structures were evaluated for buoyancy when the entire structure is completely submerged. Results are tabulated in Table 3-4 and 3-5 below for each structure. The structures are evaluated for a minimum factor of safety (FOS) of

2.0 or greater for buoyancy, 1.75 or greater for sliding, and 1.25 or greater for BDA post rotation and breakage. The minimum FOS are based on the guidelines provided in the USBR's Large Woody Material – Risk Based Design Guidelines (USBR 2014) and the potential risk to bridges and other infrastructure downstream of the proposed in-stream structures. It is recommended that each Bank Habitat Structure be intrenched into the adjacent bank with a minimum of 40 cubic yards of soil ballast.

Table 3-4. Large Wood Structure Stability Results

In-Stream Structure	Alluvium Ballast (cubic yards)	Buoyancy Factor of Safety	Sliding Factor of Safety
Bank Habitat	40	4.38	1.88
Bank Attached PALS	0	2.86	1.78

Table 3-5. Beaver Dam Analog Stability Results

In-Stream Structure	Overturning Factor of Safety	Breakage Factor of Safety
Centerline BDA	1.53	2.5

4.0 CONSTRUCTION QUANTITIES AND PRELIMINARY CONSTRUCTION COST ESTIMATE

Table 4-1 below provides a summary of the proposed project materials and quantities for the preliminary design.

Table 4-1. Summary of Proposed Project Materials and Quantities for the Preliminary Design

Construction Items	Units	Quantity
Clearing and Grubbing	Acre	1
Construction Surveying and GPS Control	Lump Sum	1
Earthen Berm Fill	Cubic Yard	6,410
Large Wood Material	Each	84
Vertical Posts	Each	347
Slash/Racking Material	Cubic Yard	558
Branches	Cubic Yard	120
Alluvium Ballast	Cubic Yard	190
Bank Habitat Structure	Each	19
Bank Attached Structure	Each	21
Centerline BDA Structure	Each	10
Riparian Plantings	Acre	1
Over Site BMPs (E.G., TESC, Traffic Control, etc.)	Lump Sum	1
Temporary Stream Crossings	Each	2
Water Control/Dewatering	Lump Sum	1
Stie Stabilization (Temporary seeding and mulching)	Acres	2
Project Cleanup and Repairs	Lump Sum	1

Table 4-2 below provides rough construction cost estimates for the preliminary design. Final construction cost estimates will also be provided at the final design stage.

Table 4-2. Construction Cost Estimates for the Preliminary Design

Clearing and Grubbing	Costs
Clearing and Grubbing	$3,000
Construction Surveying and GPS Control	$10,000
Earthen Berm	$205,120
Large Wood Material	$63,000
Vertical Posts	$4,164
Slash/Racking Material	$5,580
Branches	$7,200
Alluvium Ballast	$1,520
Bank Habitat Structure	$55,800
Bank Attached Structure	$58,669
Centerline BDA Structure	$32,625
Riparian Plantings	$8,000
Over Site BMPs (E.G., TESC, Traffic Control, etc.)	$7,500
Temporary Stream Crossings	$10,000
Water Control/Dewatering	$5,000
Stie Stabilization (Temporary seeding and mulching)	$5,000
Project Cleanup and Repairs	$5,000
Mobilization (10 percent)	$48,718
Contingency (25 percent)	$133,974
Total Cost (Nearest Thousand Dollars)	$670,000

5.0 REFERENCES

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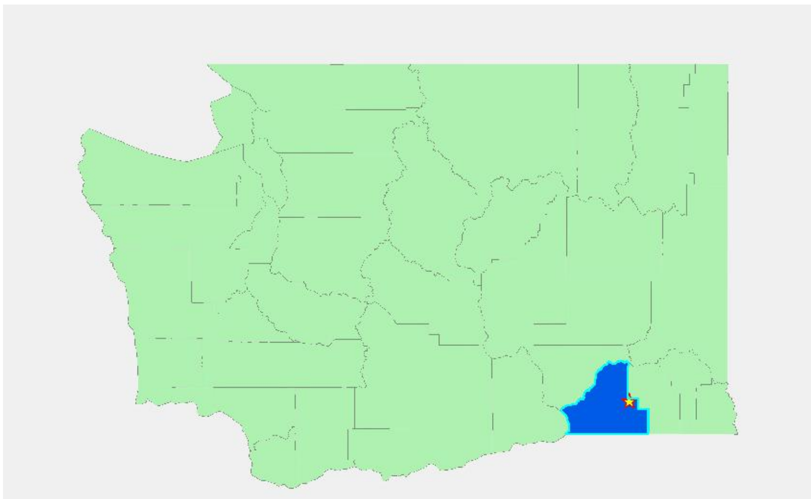
APPENDIX A: PREVIOUS DESIGNS

Cottonwood Creek PALS



Location Section 4,5 ,T6N_ R36E_

Index of Drawings

General Notes

1) The attached Construction and Material Specifications are part of this plan and shall govern this installation.

2) This installation shall be constructed to the lines and grades as shown on the drawings and detailed in the construction specifications.

3) Construction activities will be conducted in a manner that minimizes soil, water and air pollution.

4) Construction activities will be conducted in a manner consistent with all safety regulations for work necessary for this installation.

5) The installation will be operated and maintained as described in the O&M plan prepared for this operation.

Utilities

The Engineer does not make any representation to the existence or non—existence of any public and private buried and overhead utilities. Where utilities are shown on the drawing there location and depth or height is approximate. The exact location and depth or height shall be determined by the responsible utility. Any work within the utility easement will conform to the requirements of the utility.

Permits

The Engineer does not assume any responsibility in the determination, application and/or securing of any necessary permits. All permits for the construction and operation of this facility are the responsibility of the Owner, Operator, Sponsor and/or Contractor.

Review and Acceptance

The Drawings andConstruction Specifications for this project have been reviewed with me and are accepted for installation. I also acknowledge that any modifications prior to review by the Engineer before implementation may result in disapproval of this installation. I hereby acknowledge receipt of copy(ies) of this plan.

Owner/Sponsor______________________________

Date________________________________

To the best of my professional knowledge, judgement and belief, these plans meet applicable NRCS standards.

____
Lance Horning

Walla Walla County Conservation District
325 North 13th Avenue
Walla Walla, WA 99362

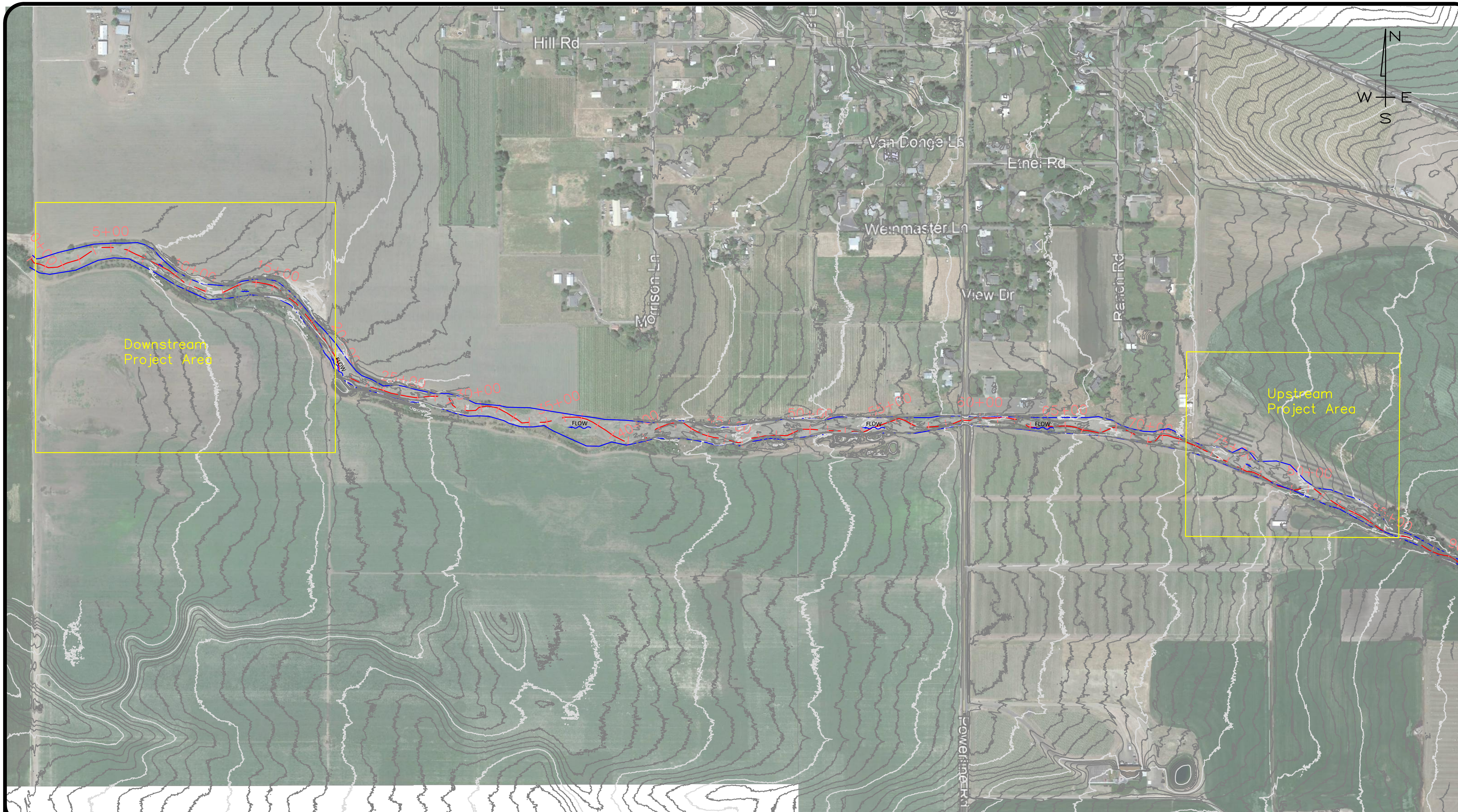
Cover Sheet

DESIGNED BY: LH
DRAWN BY: LBS
CHECKED BY: LH
APPROVED BY: LH
REVISED BY:
SCALE: NTS
DATE: 3/12/21
REVISED DATE:

Preliminary Design
Cottonwood Creek PALS
Plans

SHEET: 1

SHEET NO. 1 OF 8



Walla Walla County
Conservation District
325 North 13th Avenue
Walla Walla, WA 99362

Existing Conditions

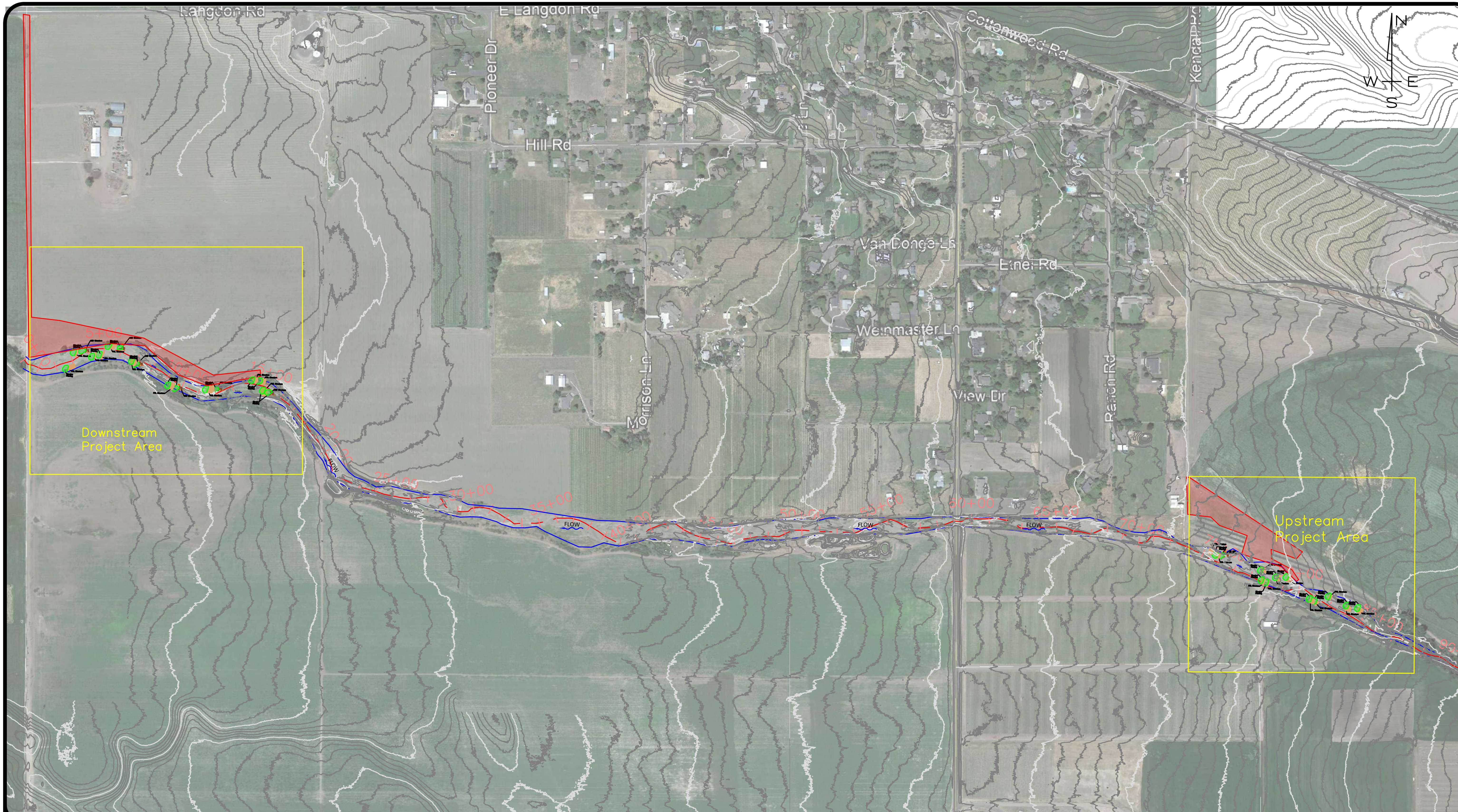
DESIGNED BY:	LH
DRAWN BY:	LH
CHECKED BY:	LH
APPROVED BY:	LH
REVISED BY:	
SCALE:	NTS
DATE:	3/3/21
REVISED DATE:	

Preliminary Design

Cottonwood Creek PALS
Plans

SHEET:
2

SHEET NO. 2 OF 8



Walla Walla County
Conservation District
325 North 13th Avenue
Walla Walla, WA 99362

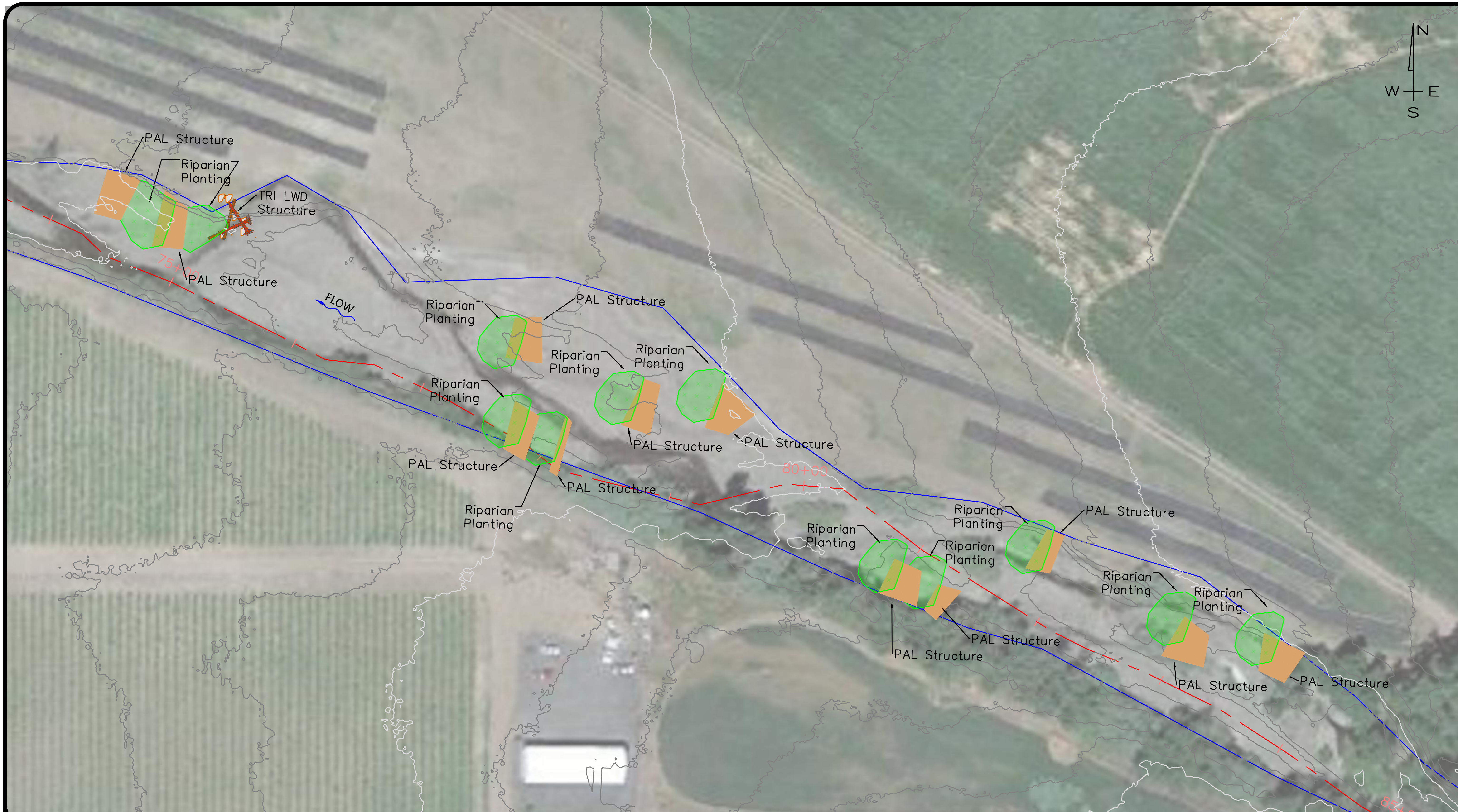
Access/Staging
Plan

DESIGNED BY: LH
DRAWN BY: LH
CHECKED BY: LH
APPROVED BY: LH
REVISED BY: LH
SCALE: NTS
DATE: 3/3/21
REVISED DATE:

Preliminary Design
Cottonwood Creek PALS
Plans

SHEET:
3

SHEET NO. 3 OF 8



Walla Walla County Conservation District
325 North 13th Avenue
Walla Walla, WA 99362

Planned Work Upstream

DESIGNED BY: LH
DRAWN BY: LH
CHECKED BY: LH
APPROVED BY: LH
REVISED BY:
SCALE: NTS
DATE: 3/3/21
REVISED DATE:

Preliminary Design
Cottonwood Creek PALS
Plans

SHEET: 4

SHEET NO. 4 OF 8

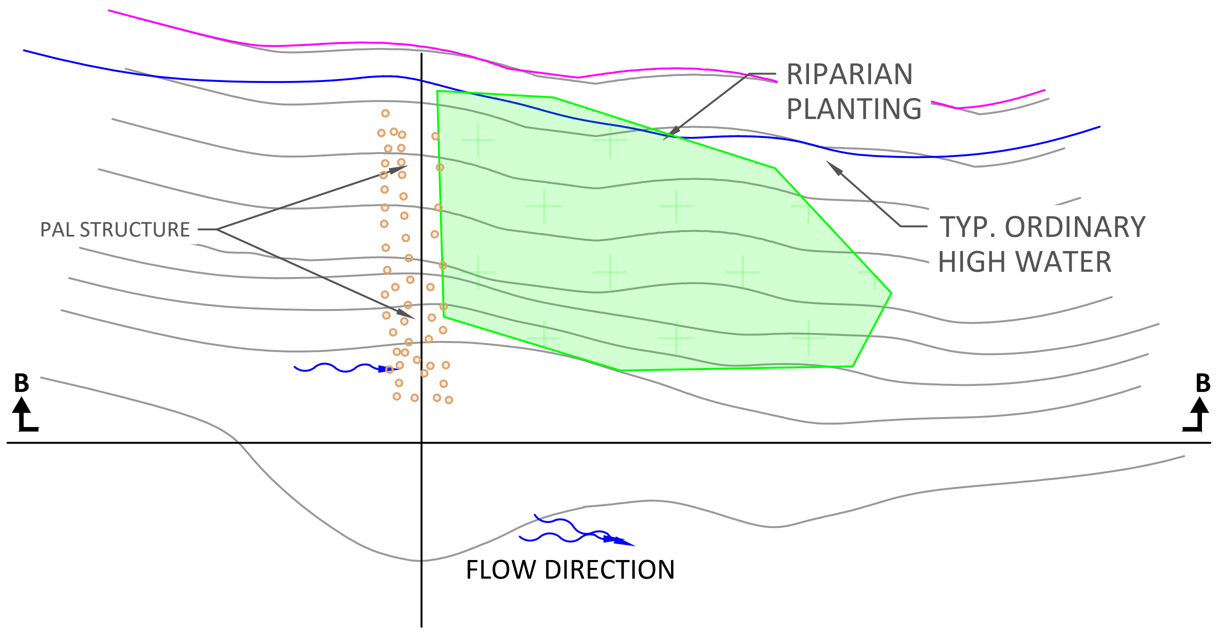
Walla Walla County Conservation District
325 North 13th Avenue
Walla Walla, WA 99362

Planned Work Downstream

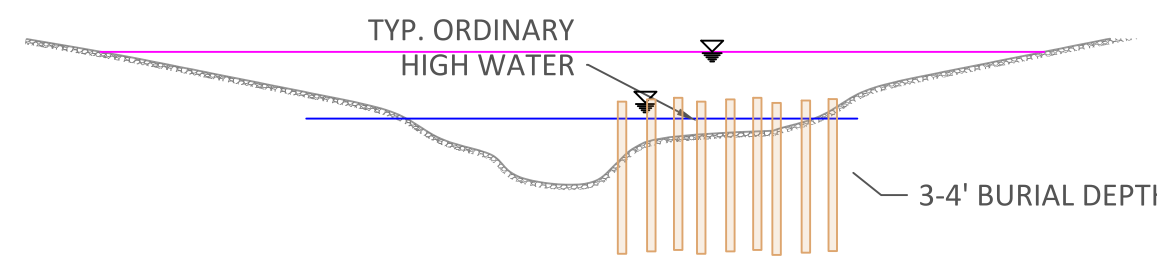
DESIGNED BY: LH
DRAWN BY: LH
CHECKED BY: LH
APPROVED BY: LH
REVISED BY:
SCALE: NTS
DATE: 3/3/21
REVISED DATE:

Preliminary Design
Cottonwood Creek PALS
Plans

SHEET: 5
SHEET NO. 5 OF 8



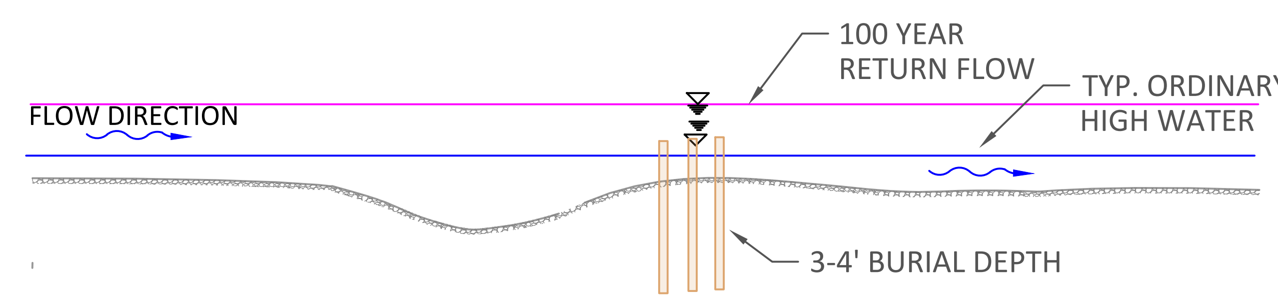
PAL-BAR TYPICAL PLAN



A PAL- BAR TYPICAL SECTION

CONSTRUCTION NOTES:

1. PAL STRUCTURE WILL BE FIELD LOCATED AT TIME OF CONSTRUCTION BY THE ENGINEER.
2. POSTS SHALL BE DRIVEN TO STAKED DEPTH.
3. PRIMARY STRUCTURAL MEMBERS ARE SHOWN. ADDITIONAL SLASH AND SMALL MEMBERS MAY BE ADDED.



B PAL-BAR TYPICAL SECTION

LWD QUANTITIES				
ITEM	DIA. (IN.)		MIN. LENGTH (FT)	QUANTITY
Posts	3-4"		6'	30-60
SLASH	5 CY.			

Walla Walla County Conservation District
325 North 13th Avenue
Walla Walla, WA 99362

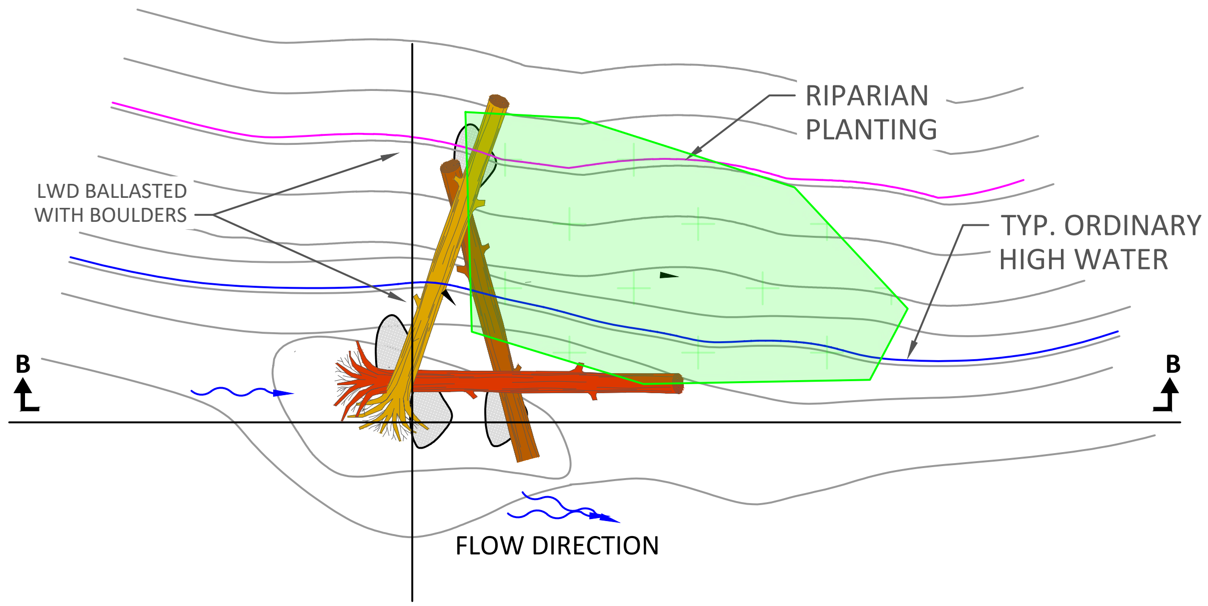
PAL-BAR Details

DESIGNED BY: LH
DRAWN BY: LH
CHECKED BY: LH
APPROVED BY: LH
REVISED BY:
SCALE: NTS
DATE: 2/3/20
REVISED DATE:

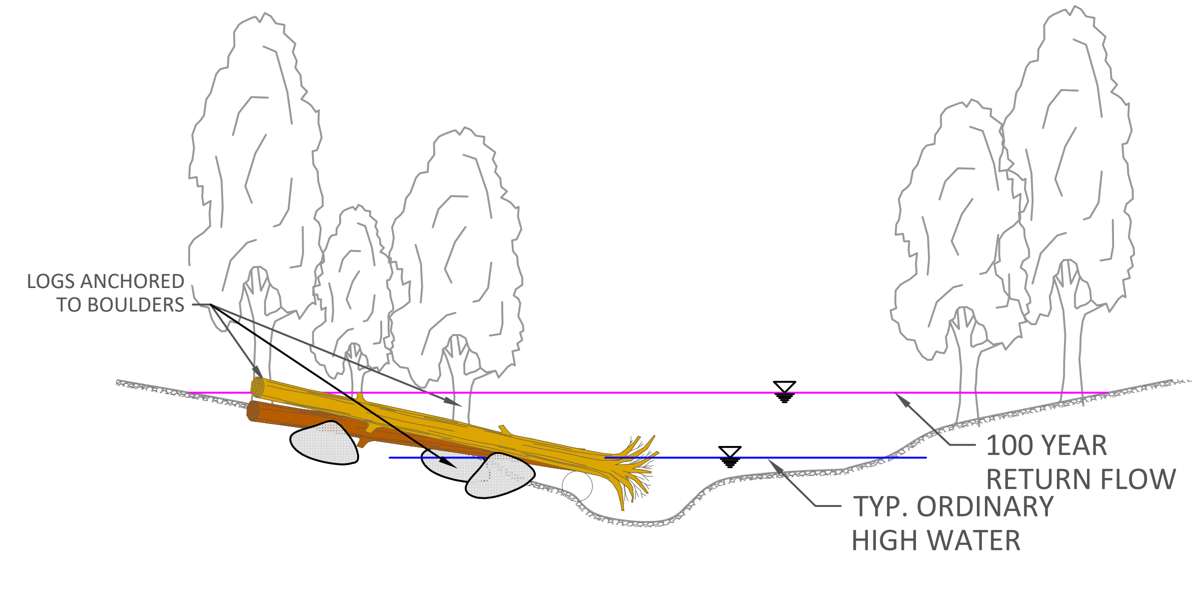
Preliminary Design
Cottonwood Creek PALS
Plans

SHEET:
6

SHEET NO. 6 OF 8



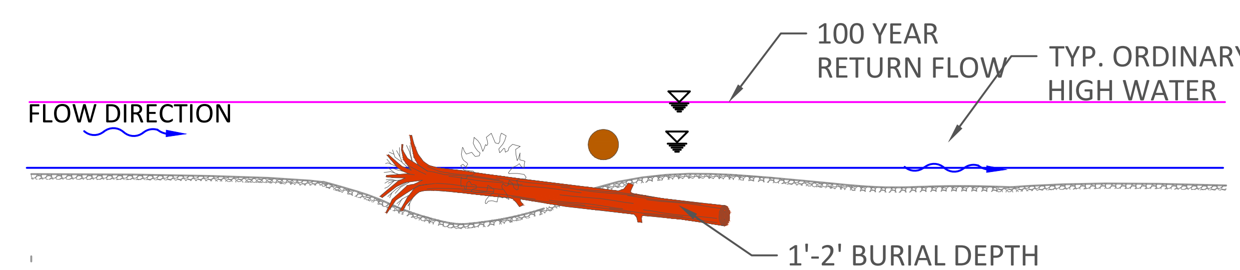
TRI LWD TYPICAL PLAN



A TRI LWD TYPICAL SECTION

CONSTRUCTION NOTES:

1. TRI LWD WILL BE FIELD LOCATED AT TIME OF CONSTRUCTION BY THE ENGINEER.
2. STRUCTURE ANCHORING IS ACHIEVED BY UTILIZING EXISTING TREES, REBAR PINS, ROCK BALLAST AND BURIAL AS DIRECTED BY ENGINEER.
3. IF STRUCTURE ANCHORING IS ACHIEVED BY BURIAL THEN A TRENCH SHALL BE EXCAVATED FOR PROPER PLACEMENT AND BACKFILLED TO EXISTING GRADE. EXCESS MATERIAL SHALL BE PLACED IN LEE OF STRUCTURE..
4. PRIMARY STRUCTURAL MEMBERS ARE SHOWN. ADDITIONAL SLASH AND SMALL MEMBERS MAY BE ADDED.



B TRI LWD TYPICAL SECTION

LWD QUANTITIES

ITEM	LOG DIA. (IN.)	ROOTWAD DIA. (IN.)	MIN. LOG LENGTH (FT)	QUANTITY
ROOTWAD LOG	18"	54"	35'	2
LOG POLE	18"		35'	1
SLASH	5 CY.			

TABLE NOTES:

1. MINIMUM LENGTHS ARE REPORTED FOR MATERIAL PROCUREMENT PURPOSES. ALL LWD SHALL BE CUT TO FIT IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS.
2. ROOTWAD LOG LENGTHS DO NOT INCLUDE THE LENGTH OF THE ROOTWAD MASS.
3. ROOTWAD LOG DIAMETER IS MEASURED AT THE BREAST HEIGHT.
4. LOG POLE DIAMETER IS MEASURED A T THE MID POINT ALONG THE LENGTH OF THE LOG.

ROCK QUANTITIES

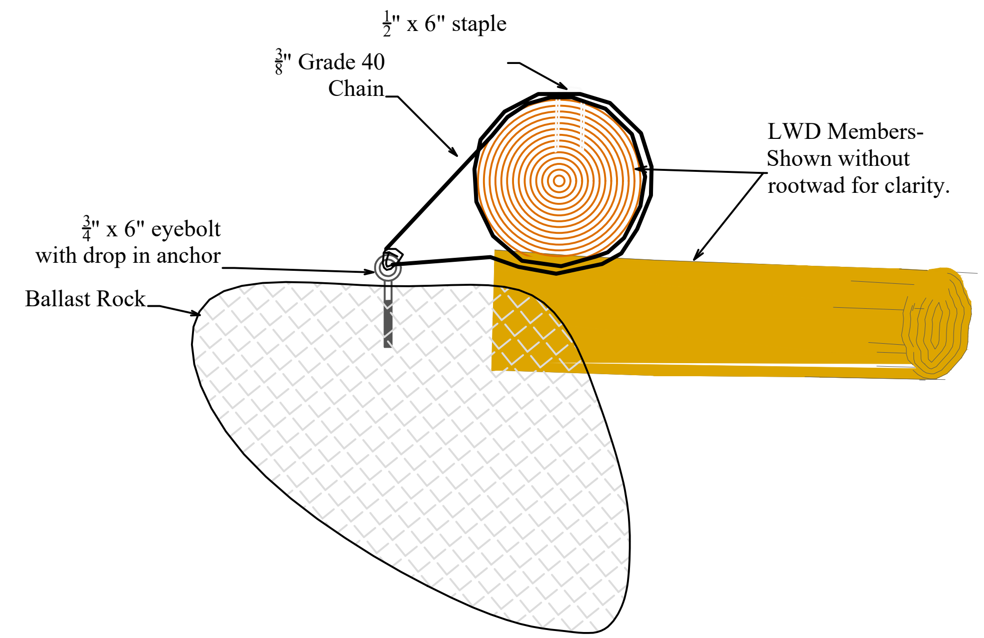
ITEM	INTERMEDIATE DIA. (Ft)	MIN. DRY WT. (Lb)	MIN # of ROCKS	QUANTITY (ton)
BOULDER	3	3000	5	7

Walla Walla County
Conservation District
325 North 13th Avenue
Walla Walla, WA 99362

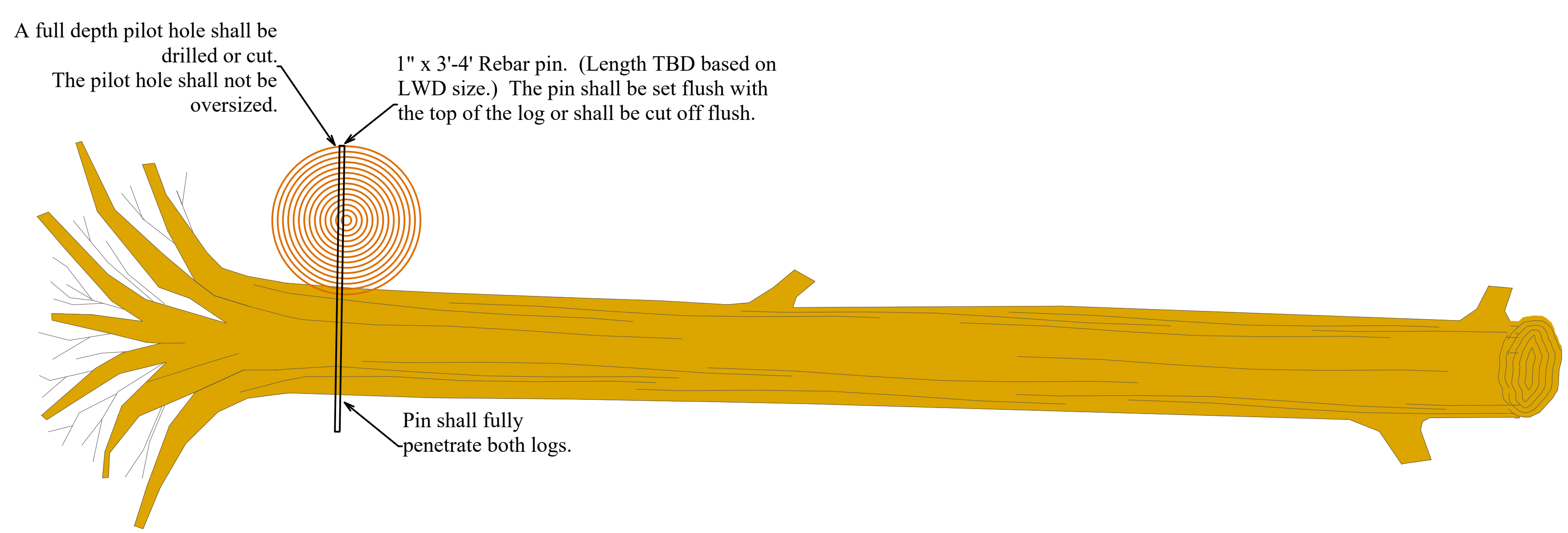
Tri LWD
Details

DESIGNED BY: LH
DRAWN BY: LH
CHECKED BY: LH
APPROVED BY: LH
REVISED BY:
SCALE: NTS
DATE: 2/3/20
REVISED DATE:

Preliminary Design
Cottonwood Creek PALS
Plans



Rock/Chain Anchor Detail



Pinning Detail

Walla Walla County Conservation District
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Walla Walla, WA 99362

Anchor Details

DESIGNED BY:	LH
DRAWN BY:	LH
CHECKED BY:	LH
APPROVED BY:	LH
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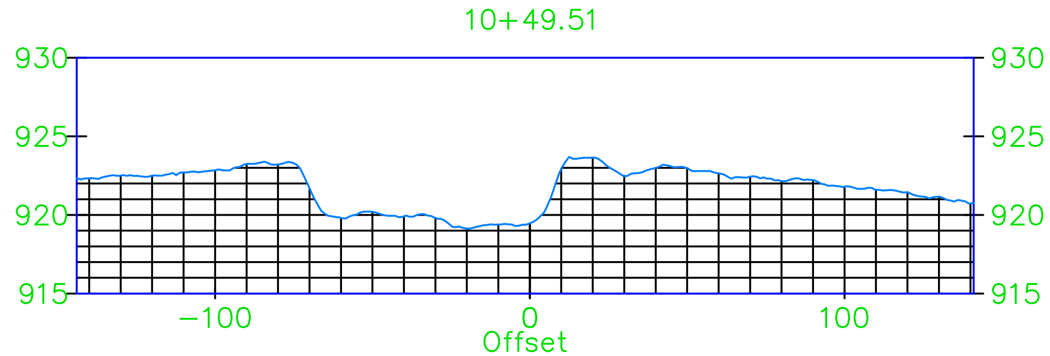
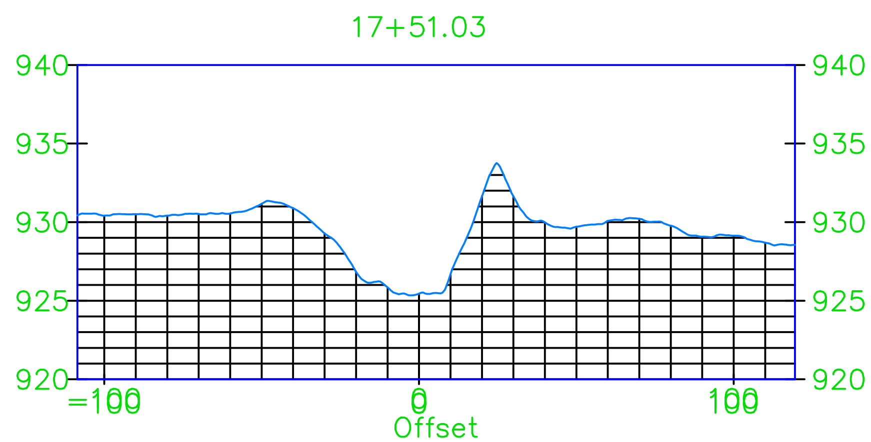
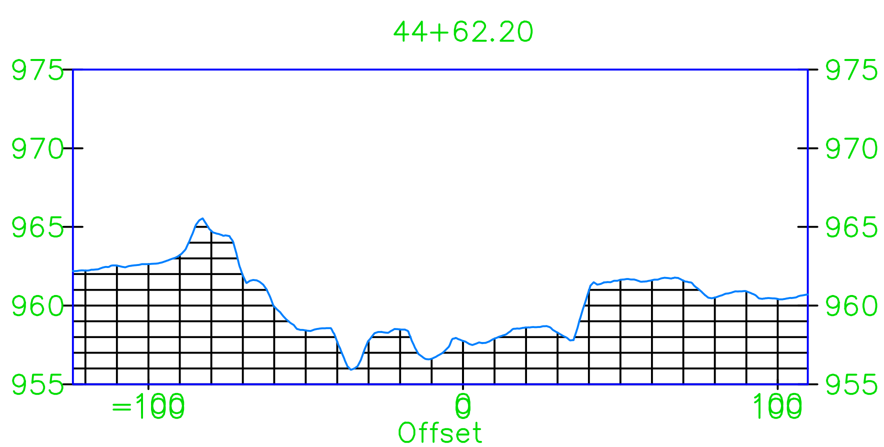
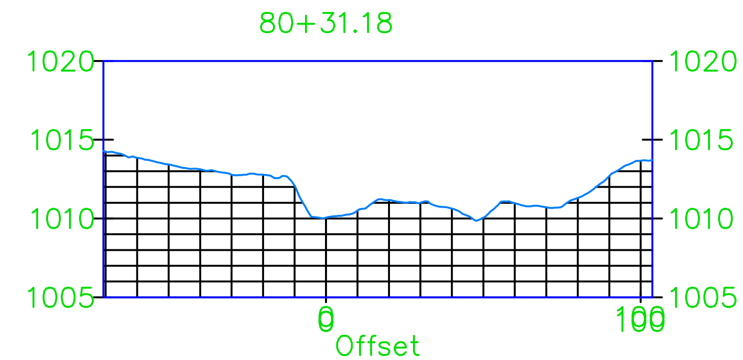
SCALE:	NTS
DATE:	2/3/20
REVISED DATE:	

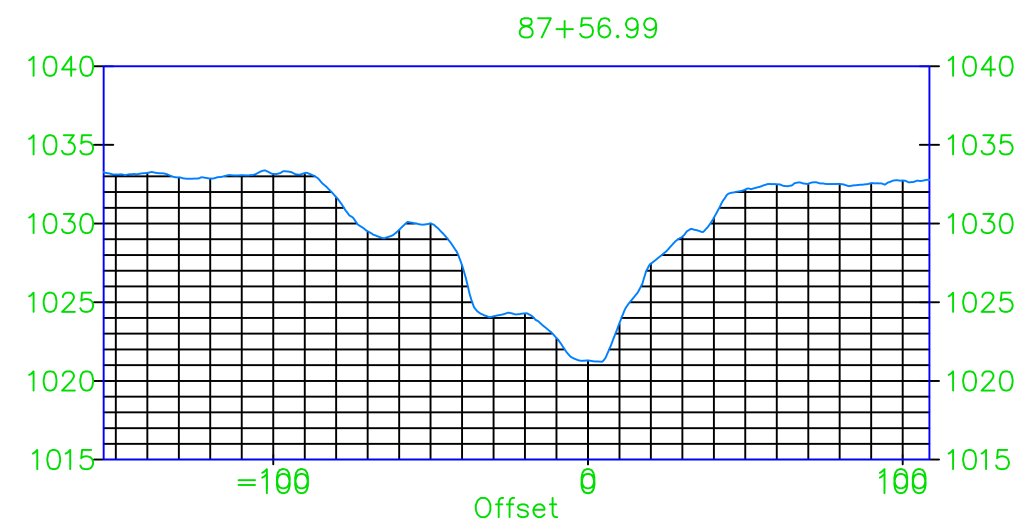
Preliminary Design
Cottonwood Creek PALS
Plans











Walla Walla County
Conservation District
325 North 13th Avenue
Walla Walla, WA 99362

Cross
Sections

DESIGNED BY:	LH
DRAWN BY:	LH
CHECKED BY:	LH
APPROVED BY:	LH
REVISED BY:	
SCALE:	NTS
DATE:	2/3/20
REVISED DATE:	

Preliminary Design
Cottonwood Creek PALS
Plans

SHEET:
X-1

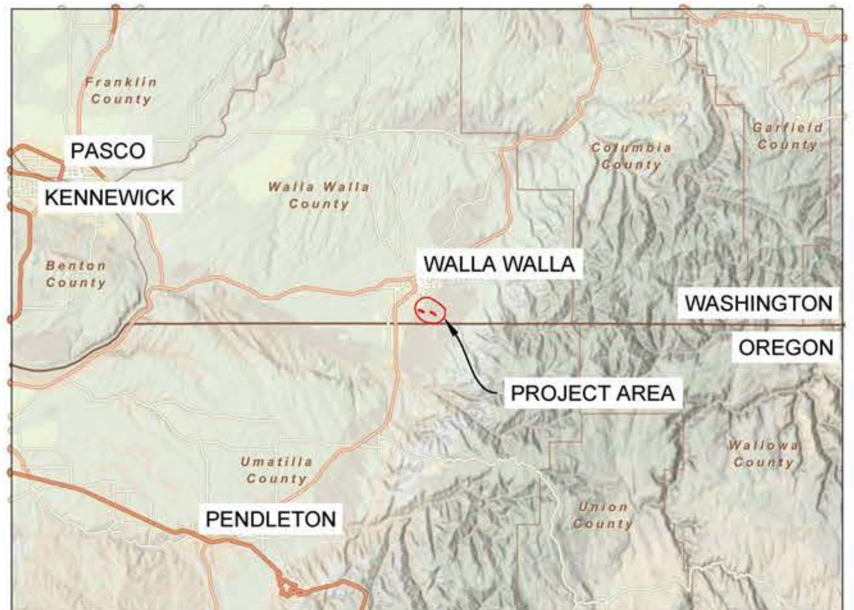
SHEET NO. 1 OF 1

APPENDIX B: COTTONWOOD CREEK PALS PRELMINARY DESIGN DRAWINGS

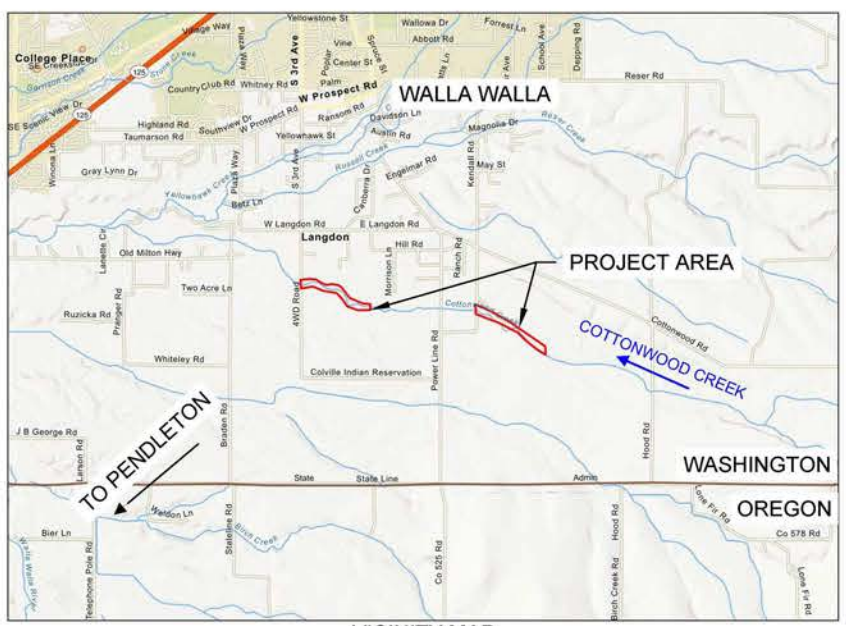
WALLA WALLA COUNTY CONSERVATION DISTRICT

COTTONWOOD CREEK PALS DESIGN

PRELIMINARY DESIGN



LOCATION MAP
SCALE: NTS



VICINITY MAP
SCALE: NTS

SHEET LIST	
DWG #	**TITLE**
G-001	COVER SHEET
G-002	CONSERVATION MEASURES
G-003 - G-006	BEST MANAGEMENT PRACTICES NOTES
E-101	GENERAL OVERVIEW - EXISTING CONDITIONS
C-101	GENERAL OVERVIEW - PROPOSED CONDITIONS
C-102 - C-104	PROPOSED CONDITIONS - DOWNSTREAM PLAN, PROFILE, AND SECTIONS
C-105 - C-107	PROPOSED CONDITIONS - UPSTREAM PLAN, PROFILE, AND SECTIONS
C-108	DETAILS - TESC
C-109 - C-110	DETAILS - HABITAT FEATURES
L-101 - L-102	PROPOSED PLANTING PLAN

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WALLA WALLA COUNTY CONSERVATION DISTRICT
ESTABLISHED 1941

NOT FOR CONSTRUCTION

PLAN SHEET SIZE ANSI B (11" X 17")

REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK PALS DESIGN

COVER SHEET

DWG. NO.: G-001

CREATED: 11/30/2022

SHEET: 1 of 20

D:\Z\PROJECTS\194-1359-0002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\01_COVER PAGE AND NOTES.DWG
PLOT DETAILS: HARVEY, SPENCER November 30, 2022 4:39 PM

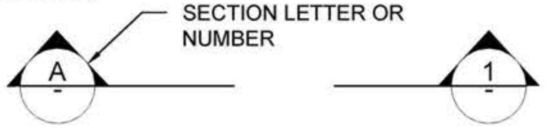
ABBREVIATIONS

1H:1V	HORIZONTAL TO VERTICAL EXAGGERATION
%	PERCENT
Ø	DIAMETER
AC	ACRE
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
APP	APPROVED BY
APPROX	APPROXIMATE
BDA	BEAVER DAM ANALOGUE
BMP	BEST MANAGEMENT PRACTICE
CHK	CHECKED BY
CO	COUNTY
CP	CONTROL POINT
CY	CUBIC YARDS
D	DEPTH
DBH	DIAMETER AT BREAST HEIGHT
DIA	DIAMETER
DWG	DRAWING
DRW	DRAWN BY
EA	EACH
EG	FOR EXAMPLE (LATIN: EXEMPLI GRATIA)
ELJ	ENGINEERED LOG JAM
ENG	ENGINEERED BY
ESA	ENDANGERED SPECIES ACT
ETC	ET CETERA
EX	EXISTING
FT, '	FOOT
ID	IDENTIFICATION
IN, "	INCH
L	LENGTH
LBS	POUNDS
LiDAR	LIGHT DETECTION AND RANGING
LT	LEFT
MAX	MAXIMUM
MI	MILE
MIN	MINIMUM
MJR	MAJOR
MNR	MINOR
N/A	NOT APPLICABLE
NAVD	NORTH AMERICAN VERTICAL DATUM OF 1988
NMFS	NATIONAL MARINE FISHERIES SERVICE
NPDES	NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEMS
NTS	NOT TO SCALE
OHW	ORDINARY HIGH WATER
PALS	POST-ASSISTED LOG
RT	RIGHT
USTA	STATION
TEMP	TEMPORARY
TESC	TEMPORARY EROSION AND SEDIMENT CONTROL
TYP	TYPICAL
USFS	UNITED STATES FOREST SERVICE
USFWS	UNITED STATES FISH AND WILDLIFE SERVICE
W/	WITH
WDFW	WASHINGTON DEPARTMENT OF FISH AND WILDLIFE
WSE	WATER SURFACE ELEVATION

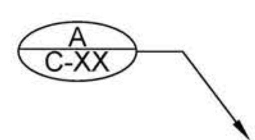
SYMBOLS

SECTIONS ARE REFERENCED IN THE FOLLOWING MANNER:

SECTION LETTER OR NUMBER

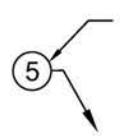


CONSTRUCTION DETAILS ARE REFERENCED IN THE FOLLOWING MANNER:



NOTES ARE REFERENCED IN THE FOLLOWING MANNER:

NOTE NUMBER



RECOMMENDED SEQUENCING FOR EACH PHASE:

IN GENERAL, THE CONSTRUCTION SEQUENCE SHALL BE:

1. MOBILIZATION; SELECTIVE SITE DEMOLITION STAKING AND FLAGGING OF SENSITIVE AREAS; CLEARING AND GRUBBING.
2. INSTALLATION OF TEMPORARY CONSTRUCTION FENCING, TEMPORARY CONSTRUCTION ACCESS ROUTES AND BRIDGES.
3. INSTALLATION AND MAINTENANCE OF CONSTRUCTION AREA BEST MANAGEMENT PRACTICES, CONSTRUCTION AND MAINTENANCE OF MATERIAL STORAGE AREAS.
4. BEFORE IN-WATER WORK WINDOW: FLOODPLAIN AND UPLANDS WORK:EXCAVATION OF NEW CHANNEL AND WETLANDS, SIDE CHANNEL, ACCLIMATION POND, HABITAT FEATURES, AND FILL FOR UPLANDS CONSTRUCTION.
5. IN-WATER WORK WINDOW: INSTALL NECESSARY FISH SALVATION EQUIPMENT, TEMPORARY CHANNEL CROSSINGS, WORK AREA ISOLATION AND DEWATERING, AND NEEDED TESC.
6. REMOVE WORK AREA ISOLATION.
7. INSTALLATION OF NATURE TRAILS AND PEDESTRIAN FOOTBRIDGES.
8. SITE RESTORATION AND REVEGETATION.
9. COMPLETE PROJECT AREA CLEANUP AND REPAIRS.

GENERAL NOTES:

1. HORIZONTAL PROJECTION: NAD83 WASHINGTON STATE PLANES, SOUTH ZONE, US FEET.
2. VERTICAL PROJECTION: NAVD88.
3. PROJECT ALIGNMENT. ELEVATION, AND STATIONING BASED ON 2019 LiDAR TOPOGRAPHIC DATA AND SUPPLEMENTED BY BATHYMETRIC SURVEY CONDUCTED BY TETRA TECH IN JUNE 2022.
4. PROPOSED PROJECT DESIGN, CONSTRUCTION ACTIVITIES, AND MATERIALS SUBJECT TO APPROVAL BY LANDOWNER.
5. AERIAL IMAGERY PROVIDED BY UNITED STATES DEPARTMENT OF AGRICULTURE NATIONAL AGRICULTURE IMAGERY PROGRAM, WALLA WALLA COUNTY, 2021.

GENERAL CONSTRUCTION NOTES:

1. THE CONTRACTOR SHALL CONSTRUCT THE RESTORATION DESIGN ELEMENTS IN ACCORDANCE WITH THE PLANS STAMPED "ISSUED FOR CONSTRUCTION". THESE PLANS WILL BE PROVIDED TO THE CONTRACTOR BY THE CONTRACTING AGENCY PRIOR TO CONSTRUCTION. WORK SHALL NOT BE DONE WITH THE CURRENT SET OF CONSTRUCTION PLANS MARKED "NOT FOR CONSTRUCTION".
2. CONTRACTOR SHALL CONTACT THE UTILITIES UNDERGROUND LOCATION CENTER 1-800-424-5555 (OR 811) BEFORE ANY EXCAVATION WORK BEGINS.
3. THE CONTRACTOR SHALL PURSUE WORK IN A CONTINUOUS AND EFFICIENT MANNER TO ENSURE TIMELY COMPLETION OF THE PROJECT.
4. ALL WORK WITHIN THE ACTIVE CHANNELS OF COTTONWOOD CREEK SHALL OCCUR WITHIN THE ALLOWABLE IN-WATER WORK WINDOW. THE CONTRACTOR TO CONFIRM IN-WATER WORK WINDOW DATES WITH WDFW DISTRICT BIOLOGIST AND OWNER'S REPRESENTATIVE PRIOR TO BEGINNING WORK.
5. ALL CONSTRUCTION ACTIVITIES SHALL MINIMIZE DISTURBANCE TO AND MAXIMIZE RE-USE OF EXISTING RIPARIAN VEGETATION.
6. THE CONTRACTOR SHALL PROTECT ALL CONTROL POINTS DURING CONSTRUCTION ACTIVITIES AND THE CONTRACTOR WILL PLACE ADEQUATE STAKING SO THAT THE OWNER'S REPRESENTATIVE CAN VERIFY ELEVATION AS WORK ACTIVITIES ARE PROGRESSING.
7. ALL TESC MEASURES AND WORK ACTIVITIES ARE DESIGNED TO ACCOMMODATE THE EXPECTED ENVIRONMENTAL CONDITIONS AT TIME OF CONSTRUCTION (I.E., SEASONAL PRECIPITATION, SOIL MOISTURE LEVELS, GROUNDWATER LEVELS, CHANNEL FLOW, ETC.). CONTRACTOR SHALL RESTRICT WORK ACTIVITIES IF ENVIRONMENTAL CONDITIONS SIGNIFICANTLY DEVIATE FROM THE EXPECTED CONDITIONS. WORK CONDITIONS MAY DIFFER DURING CONSTRUCTION AND SHALL BE FIELD ADJUSTED TO CONFORM WITH THE GUIDELINES IN THE USFWS PROJECT PROGRAMMATIC CONTRACTORS HANDBOOK, VERSION 1.2 (USFWS 2020). ALL WORK ACTIVITIES SHALL BE SUSPENDED AT THE DISCRETION OF THE OWNER'S REPRESENTATIVE.
8. CONTRACTOR SHALL PROVIDE AN EROSION AND SEDIMENT CONTROL AND DEWATERING PLAN TO OWNER WITHIN TEN (10) DAYS OF NOTICE TO PROCEED.

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GENERAL NOTES AND ABBREVIATIONS

DWG. NO.: G-002

CREATED: 11/30/2022

BEST MANAGEMENT PRACTICES APPLICABLE TO ALL ACTIONS

THE ACTIVITIES COVERED UNDER THE PROJECT PERMITS ARE INTENDED TO PROTECT AND RESTORE FISH AND WILDLIFE HABITAT WITH LONG-TERM BENEFITS TO ENDANGERED SPECES ACT (ESA)-LISTED SPECIES. THE FOLLOWING BEST MANAGEMENT PRACTICES WILL BE APPLIED TO ALL ACTIONS OF THIS PROJECT.

PROJECT DESIGN AND SITE PREPARATION.

1. STATE AND FEDERAL PERMITS.

A. CONTRACTOR MUST OBTAIN AND IMPLEMENT THE MOST RECENT NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM CONSTRUCTION STORMWATER GENERAL PERMIT OR WASHINGTON STATE EQUAL BEFORE PROJECT IMPLEMENTATION.

B. ALL APPLICABLE TERMS AND CONDITIONS OF THE U.S. ARMY CORPS OF ENGINEERS CLEAN WATER ACT SECTION 404 AUTHORIZATION AND SECTION 401 WATER QUALITY CERTIFICATIONS WOULD BE IMPLEMENTED TO MINIMIZE PROJECT-RELATED CHANGES TO TURBIDITY AND DISSOLVED OXYGEN CONCENTRATIONS.

C. COPIES OF ALL APPLICABLE STATE AND FEDERAL PERMITS MUST BE AVAILABLE ON SITE.

D. RESTRICT CONSTRUCTION ACTIVITIES TO THE APPROVED WORK WINDOWS AND TIMES.

E. IF YOU DISCOVER ANY PREVIOUSLY UNKNOWN HISTORIC, CULTURAL OR ARCHEOLOGICAL REMAINS AND ARTIFACTS WHILE ACCOMPLISHING THE ACTIVITY AUTHORIZED BY THIS PERMIT, YOU MUST IMMEDIATELY NOTIFY THE DISTRICT ENGINEER OF WHAT YOU HAVE FOUND, AND TO THE MAXIMUM EXTENT PRACTICABLE, AVOID CONSTRUCTION ACTIVITIES THAT MAY AFFECT THE REMAINS AND ARTIFACTS UNTIL THE REQUIRED COORDINATION HAS BEEN COMPLETED. THE DISTRICT ENGINEER WILL INITIATE THE FEDERAL, TRIBAL, AND STATE COORDINATION REQUIRED TO DETERMINE IF THE ITEMS OR REMAINS WARRANT A RECOVERY EFFORT OR IF THE SITE IS ELIGIBLE FOR LI STING IN THE NATIONAL REGISTER OF HISTORIC PLACES.

2. TIMING OF IN-WATER WORK.

A. SEE GENERAL CONSTRUCTION NOTES ON SHEET G-002 FOR APPLICABLE IN-WATER WORK DATES.

3. SITE LAYOUT AND FLAGGING.

A. PERMITTEES MUST CLEARLY MARK ALL CONSTRUCTION AREA BOUNDARIES BEFORE BEGINNING WORK ON PROJECTS THAT INVOLVE GRADING OR PLACEMENT OF FILL.

B. BOUNDARY MARKERS AND/OR CONSTRUCTION FENCING MUST BE MAINTAINED AND CLEARLY VISIBLE FOR THE DURATION OF CONSTRUCTION.

C. FLAGGING SENSITIVE AREAS - PRIOR TO CONSTRUCTION, CLEARLY MARK CRITICAL RIPARIAN VEGETATION AREAS, WETLANDS, CULTURAL AND OTHER SENSITIVE SITES TO BE AVOIDED.

D. KNOWN HISTORIC HIGH PROBABILITY AREAS AND AVOIDANCE AREAS WILL BE APPROPRIATELY FLAGGED BY ARCHEOLOGIST PRIOR TO ANY WORK DONE ON THE SITE.

4. TEMPORARY ACCESS ROADS AND PATHS.

A. EXISTING ROADWAYS WILL BE USED WHENEVER POSSIBLE.

B. MINIMIZE THE NUMBER OF TEMPORARY ACCESS ROADS AND TRAVEL PATHS TO LESSEN SOIL DISTURBANCE AND COMPACTION AND IMPACTS TO VEGETATION.

C. TEMPORARY ACCESS ROADS WILL NOT BE BUILT ON SLOPES WHERE GRADE, SOIL, OR OTHER FEATURES SUGGEST A LIKELIHOOD OF EXCESSIVE EROSION OR FAILURE.

D. OUTSLOPE TEMPORARY ROADS AND SKID TRAILS TO AVOID SEDIMENT DELIVERY TO STREAMS AND WETLANDS AND AVOID INSTALLING TEMPORARY ROADS OR SKID TRAILS IN WETLANDS TO MEET AQUATIC CONSERVATION STRATEGY RF-2.

E. WHEN NECESSARY, TEMPORARY ACCESS ROADS WILL BE OBLITERATED OR REVEGETATED.

F. TEMPORARY ROADS IN WET OR FLOODED AREAS WILL BE RESTORED BY THE END OF THE APPLICABLE IN-WATER WORK PERIOD. CONSTRUCTION OF NEW PERMANENT ROADS IS NOT PERMITTED.

5. TEMPORARY CROSSINGS OF SENSITIVE AQUATIC AREAS.

A. MINIMIZE NUMBER AND LENGTH OF STREAM CROSSINGS.

B. SUCH CROSSINGS WILL BE AT RIGHT ANGLES AND AVOID POTENTIAL SPAWNING AREAS TO THE GREATEST EXTENT POSSIBLE.

C. STREAM CROSSINGS SHALL NOT INCREASE THE RISK OF CHANNEL RE-ROUTING AT LOW AND HIGH-WATER CONDITIONS.

D. AFTER PROJECT COMPLETION, TEMPORARY STREAM CROSSINGS WILL BE ABANDONED, AND THE STREAM CHANNEL AND BANKS RESTORED.

E. PERMITTEES SHOULD AVOID AND MINIMIZE REMOVAL OF NATIVE VEGETATION (INCLUDING SUBMERGED AQUATIC VEGETATION) TO THE MAXIMUM EXTENT POSSIBLE.

6. STAGING, STORAGE, AND STOCKPILE AREAS.

A. STAGING AREA - ESTABLISH STAGING AREAS FOR STORAGE OF VEHICLES, EQUIPMENT, AND FUELS TO MINIMIZE EROSION INTO OR CONTAMINATION OF STREAMS AND FLOODPLAINS.
   1. AVOID PUTTING STAGING AREAS AND OTHER WORK AREAS IN AREAS WHERE THERE ARE HIGH SNAG DENSITIES
   2. AVOID PUTTING STAGING AREAS AND OTHER WORK AREAS IN AREAS WITH UNIQUE VEGETATION OR LARGE DIAMETER TREES
   3. NO TOPOGRAPHICAL RESTRICTIONS - PLACE STAGING AREA 150 FEET OR MORE FROM ANY NATURAL WATER BODY OR WETLAND IN AREAS WHERE TOPOGRAPHY DOES NOT RESTRICT SUCH A DISTANCE.
   4. TOPOGRAPHICAL RESTRICTIONS -PLACE STAGING AREA AWAY FROM ANY NATURAL WATER BODY OR WETLAND TO THE GREATEST EXTENT POSSIBLE IN AREAS WITH HIGH TOPOGRAPHICAL RESTRICTION, SUCH AS CONSTRICTED VALLEY TYPES.

B. STOCKPILE MATERIALS - MINIMIZE CLEARING AND GRUBBING ACTIVITIES WHEN PREPARING STAGING, PROJECT, AND OR STOCKPILE AREAS. ANY LARGE WOOD, TOPSOIL, AND NATIVE CHANNEL MATERIAL DISPLACED BY CONSTRUCTION WILL BE STOCKPILED FOR USE DURING SITE RESTORATION. MATERIALS USED FOR IMPLEMENTATION OF AQUATIC RESTORATION CATEGORIES (E.G., LARGE WOOD, BOULDERS, FENCING MATERIAL) MAY BE STAGED WITHIN THE 100-YEAR FLOODPLAIN.

C. DURING EXCAVATION, STOCKPILE NATIVE STREAMBED MATERIALS ABOVE THE BANK FULL ELEVATION, WHERE IT CANNOT REENTER THE STREAM, FOR LATER USE.

7. EQUIPMENT.

A. CHOICE OF EQUIPMENT - HEAVY EQUIPMENT WILL BE COMMENSURATE WITH THE PROJECT AND OPERATED IN A MANNER THAT MINIMIZES ADVERSE EFFECTS TO THE ENVIRONMENT (E.G., MINIMALLY-SIZED, LOW-PRESSURE TIRES, MINIMAL HARD TURN PATHS FOR TRACKED VEHICLES, TEMPORARY MATS OR PLATES WITHIN WET AREAS OR SENSITIVE SOILS).

B. FUELING AND CLEANING AND INSPECTION FOR PETROLEUM PRODUCTS AND INVASIVE WEEDS
   1. ALL EQUIPMENT USED FOR INSTREAM WORK WILL BE CLEANED FOR PETROLEUM ACCUMULATIONS, DIRT, PLANT MATERIAL (TO PREVENT THE SPREAD OF NOXIOUS WEEDS), AND LEAKS REPAIRED PRIOR TO ENTERING THE PROJECT AREA. SUCH EQUIPMENT INCLUDES LARGE MACHINERY, STATIONARY POWER EQUIPMENT(E.G., GENERATORS, CANES), AND GAS-POWERED EQUIPMENT WITH TANKS LARGER THAN FIVE GALLONS.
   2. STORE AND FUEL EQUIPMENT IN STAGING AREAS AFTER DAILY USE.
   3. INSPECT DAILY FOR FLUID LEAKS BEFORE LEAVING THE VEHICLE STAGING AREA FOR OPERATION.
   4. THOROUGHLY CLEAN EQUIPMENT BEFORE OPERATION BELOW ORDINARY HIGH WATER OR WITHIN 50 FEET OF ANY NATURAL WATER BODY OR AREAS THAT DRAIN DIRECTLY TO STREAMS OR WETLANDS AND AS OFTEN AS NECESSARY DURING OPERATION TO REMAIN GREASE FREE.

C. WORK FROM TOP OF BANK - TO THE EXTENT FEASIBLE, HEAVY EQUIPMENT WILL WORK FROM THE TOP OF THE BANK, UNLESS WORK INSTREAM WOULD RESULT IN LESS DAMAGE TO THE AQUATIC ECOSYSTEM.

D. HEAVY EQUIPMENT OPERATING WITHIN AREAS DESIGNATED AS GROUND BASED WILL BE CONFINED TO OPERATING ON LANDINGS, APPROVED ROADS OR PREPARED SLASH MAT TRAILS THAT ARE AT LEAST ONE FOOT IN DEPTH AND RESULT IN NO SIGNIFICANT INCREASE IN SOIL BULK DENSITY.

E. HEAVY EQUIPMENT USED FOR MECHANICAL TREE REMOVAL MUST BE EQUIPPED WITH A BOOM CAPABLE OF REACHING CUT TREES OR SLASH WHILE MAINTAINING CONFINEMENT TO LANDINGS, APPROVED ROADS OR PREPARED SLASH MAT TRAILS.

8. EROSION AND POLLUTION CONTROL.

A. TEMPORARY IMPACTS TO WATERS OF THE U.S. MUST NOT EXCEED SIX MONTHS UNLESS THE PROSPECTIVE PERMITTEE REQUESTS AND RECEIVES A WAIVER BY THE DISTRICT ENGINEER. TEMPORARY IMPACTS TO WATERS OF THE U.S. MUST BE IDENTIFIED IN THE PRE-CONSTRUCTION NOTIFICATION (PCN).

B. ALL EPA NPDES PERMITS FOR CONSTRUCTION STORMWATER MUST ADDRESS THE MINIMUM FEDERAL EFFLUENT LIMITATION GUIDELINES FOR THE CONSTRUCTION AND DEVELOPMENT POINT SOURCE CATEGORY (REFERRED TO AS "THE C&D RULE"). THE C&D RULE FOUND IN 40 CFR 450.21 ESTABLISHES MINIMUM NPDES EFFLUENT LIMITATIONS, SUCH AS:
   1. DESIGN, INSTALL, AND MAINTAIN EFFECTIVE EROSION AND SEDIMENT CONTROLS, AND POLLUTION PREVENTION MEASURES, TO MINIMIZE THE DISCHARGE OF POLLUTANTS;
   2. STABILIZE DISTURBED AREAS IMMEDIATELY WHEN CONSTRUCTION HAS CEASED AND WILL NOT RESUME FOR MORE THAN 14 CALENDAR DAYS;
   3. PROHIBIT THE DEWATERING DISCHARGES UNLESS MANAGED BY APPROPRIATE CONTROLS; AND
   4. PROHIBIT THE DISCHARGE OF:
      4.1. WASTEWATER FROM CONCRETE WASHOUT (UNLESS MANAGED BY APPROPRIATE CONTROL), OR WASHOUT/CLEANOUT OF STUCCO, PAINT, FORM RELEASE OILS, OTHER WASTEWATER MATERIALS;
      4.2. FUELS, OILS, OR OTHER POLLUTANTS USED FOR VEHICLES; AND
      4.3. SOAPS OR SOLVENTS TO WASH VEHICLES AND EQUIPMENT.

C. IMPLEMENT THE FOLLOWING POLLUTION AND EROSION CONTROL MEASURES:
   1. PROJECT CONTACT: IDENTIFY A PROJECT CONTACT (NAME, PHONE NUMBER, AND ADDRESS) THAT WILL BE RESPONSIBLE FOR IMPLEMENTING POLLUTION AND EROSION CONTROL MEASURES.
   2. LIST AND DESCRIBE ANY HAZARDOUS MATERIAL THAT WOULD BE USED AT THE PROJECT SITE, INCLUDING PROCEDURES FOR INVENTORY, STORAGE, HANDLING, AND MONITORING; NOTIFICATION PROCEDURES; SPECIFIC CLEAN-UP AND DISPOSAL INSTRUCTIONS FOR DIFFERENT PRODUCTS AVAILABLE ON THE SITE; PROPOSED METHODS FOR DISPOSAL OF SPILLED MATERIAL, AND EMPLOYEE TRAINING FOR SPILL CONTAINMENT.
   3. TEMPORARILY STORE ANY WASTE LIQUIDS GENERATED AT THE STAGING AREAS UNDER COVER ON AN IMPERVIOUS SURFACE, SUCH AS TARPAULINS, UNTIL SUCH TIME THEY CAN BE PROPERLY TRANSPORTED TO AND TREATED AT AN APPROVED FACILITY FOR TREATMENT OF HAZARDOUS MATERIALS.
   4. PROCEDURES BASED ON BEST MANAGEMENT PRACTICES TO CONFINE, REMOVE, AND DISPOSE OF CONSTRUCTION WASTE, INCLUDING EVERY TYPE OF DEBRIS, DISCHARGE WATER, CONCRETE, CEMENT, GROUT, WASHOUT FACILITY, WELDING SLAG, PETROLEUM PRODUCT, OR OTHER HAZARDOUS MATERIALS GENERATED, USED, OR STORED ON-SITE.
   5. BEST MANAGEMENT PRACTICES TO CONFINE VEGETATION AND SOIL DISTURBANCE TO THE MINIMUM AREA, AND MINIMUM LENGTH OF TIME, AS NECESSARY TO COMPLETE THE ACTION, AND OTHERWISE PREVENT OR MINIMIZE EROSION ASSOCIATED WITH THE ACTION AREA.
   6. NO UNCURED CONCRETE OR FORM MATERIALS WILL BE ALLOWED TO ENTER THE ACTIVE STREAM CHANNEL.
   7. STEPS TO CEASE WORK UNDER HIGH FLOWS, EXCEPT FOR EFFORTS TO AVOID OR MINIMIZE RESOURCE DAMAGE.

D. TEMPORARY EROSION CONTROLS - PLACE SEDIMENT BARRIERS PRIOR TO CONSTRUCTION AROUND SITES WHERE SIGNIFICANT LEVELS OF EROSION MAY ENTER THE STREAM DIRECTLY OR THROUGH ROAD DITCHES.

E. TEMPORARY EROSION CONTROLS WILL BE IN PLACE BEFORE ANY SIGNIFICANT ALTERATION OF THE ACTION SITE AND WILL BE REMOVED ONCE THE SITE HAS BEEN STABILIZED FOLLOWING CONSTRUCTION ACTIVITIES.

F. SUITABLE MATERIAL. ANY MATERIAL OR STRUCTURE PLACED IN WATERS OF THE UNITED STATES, WHETHER TEMPORARY OR PERMANENT, SHALL BE FREE OF TOXIC POLLUTANTS IN TOXIC AMOUNTS

G. SHORT-TERM STABILIZATION - MEASURES MAY INCLUDE THE USE OF NON-NATIVE STERILE SEED MIX (WHEN NATIVE SEEDS ARE NOT AVAILABLE), WEED-FREE CERTIFIED STRAW, JUTE MATTING, AND OTHER SIMILAR TECHNIQUES. SHORT-TERM STABILIZATION MEASURES WILL BE MAINTAINED UNTIL PERMANENT EROSION CONTROL MEASURES ARE EFFECTIVE. STABILIZATION MEASURES WILL BE INSTIGATED WITHIN THREE DAYS OF CONSTRUCTION COMPLETION.

H. PERMANENT EROSION CONTROL AND PLANTING BARRIER CLOTH/JUTE MATTING SHOULD BE COMPOSED OF NATURAL FIBER MATERIALS, NO PLASTICS OR SYNTHETIC MATERIALS SHOULD BE LEFT ON SITE AFTER PROJECT COMPLETION.

9. SPILL PREVENTION, CONTROL, AND COUNTER MEASURES.

A. PROCEDURES TO CONTAIN AND CONTROL A SPILL OF ANY HAZARDOUS MATERIAL GENERATED, USED OR STORED ON-SITE, INCLUDING NOTIFICATION OF PROPER AUTHORITIES. ENSURE THAT MATERIALS FOR EMERGENCY EROSION AND HAZARDOUS MATERIALS CONTROL ARE ONSITE (E.G., SILT FENCE, STRAW BALES, OIL-ABSORBING FLOATING BOOM WHENEVER SURFACE WATER IS PRESENT).

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CONSERVATION MEASURES

10. INVASIVE SPECIES CONTROL
A. IMPORTED GRAVEL MUST BE FREE OF INVASIVE SPECIES AND NON-NATIVE SEEDS. IF NECESSARY, WASH GRAVEL PRIOR TO PLACEMENT.
B. CONDUCT POST-CONSTRUCTION MONITORING AND TREATMENT OR REMOVAL OF INVASIVE PLANTS UNTIL NATIVE PLANT SPECIES ARE WELL ESTABLISHED.
C. ALL EQUIPMENT USED FOR INSTREAM WORK WILL BE CLEANED FOR DIRT AND PLANT MATERIAL (TO PREVENT THE SPREAD OF NOXIOUS WEEDS). SUCH EQUIPMENT INCLUDES LARGE MACHINERY, STATIONARY POWER EQUIPMENT(E.G., GENERATORS, CANES), AND GAS-POWERED EQUIPMENT WITH TANKS LARGER THAN FIVE GALLONS.

WORK AREA ISOLATION AND FISH SALVAGE.

1. AREA ISOLATION
A. ISOLATE THE CONSTRUCTION AREA AND REMOVE FISH FROM A PROJECT SITE FOR PROJECTS THAT INCLUDE CONCENTRATED AND MAJOR EXCAVATION AT A SINGLE LOCATION WITHIN THE STREAM CHANNEL. THIS CONDITION WILL TYPICALLY APPLY TO THE FOLLOWING AQUATIC RESTORATION CATEGORIES: FISH PASSAGE RESTORATION; DAM, TIDE GATE, AND LEGACY STRUCTURE REMOVAL; CHANNEL RECONSTRUCTION/RELOCATION.
B. AQUATIC LIFE MOVEMENTS. THE PERMITTEE SHALL NOT SUBSTANTIALLY DISRUPT THE NECESSARY LIFE-CYCLE MOVEMENT OF THOSE SPECIES OF AQUATIC LIFE INDIGENOUS TO THE WATERBODY, INCLUDING THOSE SPECIES THAT NORMALLY MIGRATE THROUGH THE AREA, UNLESS THE PRIMARY PURPOSE OF THE ACTIVITY IS TO TEMPORARILY IMPOUND WATER.
C. MANAGEMENT OF WATER FLOWS. TO THE MAXIMUM EXTENT PRACTICABLE, THE ACTIVITY MUST BE DESIGNED TO MAINTAIN DOWNSTREAM FLOW CONDITIONS. FURTHERMORE, THE ACTIVITY SHALL NOT PERMANENTLY RESTRICT OR IMPEDE THE PASSAGE OF NORMAL OR EXPECTED HIGH FLOWS UNLESS THE PRIMARY PURPOSE OF THE FILL IS TO TEMPORARILY IMPOUND WATER. THE PERMITTEE SHOULD LIMIT THE WORK CONDUCTED IN WATERS OF THE UNITED STATES TO LOW-OR NO-FLOW PERIODS.

2. FISH SALVAGE.
A. ISOLATE CAPTURE AREA:
1. INSTALL BLOCK NETS AT UP AND DOWNSTREAM LOCATIONS OUTSIDE OF THE CONSTRUCTION ZONE TO EXCLUDE FISH FROM ENTERING THE PROJECT AREA.
2. LEAVE NETS SECURED TO THE STREAM CHANNEL BED AND BANKS UNTIL CONSTRUCTION ACTIVITIES WITHIN THE STREAM CHANNEL ARE COMPLETE.
3. IF BLOCK NETS OR TRAPS REMAIN IN PLACE MORE THAN ONE DAY, MONITOR THE NETS AND OR TRAPS AT LEAST ON A DAILY BASIS TO ENSURE THEY ARE SECURED TO THE BANKS AND FREE OF ORGANIC ACCUMULATION AND TO MINIMIZE FISH PREDATION IN THE TRAP.
B. CAPTURE AND RELEASE:
1. FISH TRAPPED WITHIN THE ISOLATED WORK AREA WILL BE CAPTURED AND RELEASED AS PRUDENT TO MINIMIZE THE RISK OF INJURY, THEN RELEASED AT A SAFE RELEASE SITE, PREFERABLY UPSTREAM OF THE ISOLATED REACH IN A POOL OR OTHER AREA THAT PROVIDES COVER AND FLOW REFUGE.
2. COLLECT FISH IN THE BEST MANNER TO MINIMIZE POTENTIAL STRANDING AND STRESS BY SEINE OR DIP NETS AS THE AREA IS SLOWLY DEWATERED, BAITED MINNOW TRAPS PLACED OVERNIGHT, OR ELECTROFISHING (IF OTHER OPTIONS ARE INEFFECTIVE). FISH MUST BE HANDLED WITH EXTREME CARE AND KEPT IN WATER THE MAXIMUM EXTENT POSSIBLE DURING TRANSFER PROCEDURES.
3. A HEALTHY ENVIRONMENT FOR THE STRESSED FISH SHALL BE PROVIDED--LARGE BUCKETS (FIVE-GALLON MINIMUM TO PREVENT OVERCROWDING) AND MINIMAL HANDLING OF FISH. PLACE LARGE FISH IN BUCKETS SEPARATE FROM SMALLER PREY-SIZED FISH. MONITOR WATER TEMPERATURE IN BUCKETS AND WELL-BEING OF CAPTURED FISH. IF BUCKETS ARE NOT BEING IMMEDIATELY TRANSPORTED, USE AERATORS TO MAINTAIN WATER QUALITY. AS RAPIDLY AS POSSIBLE, BUT AFTER FISH HAVE RECOVERED, RELEASE FISH.
4. IN CASES WHERE THE STREAM IS INTERMITTENT UPSTREAM, RELEASE FISH IN DOWNSTREAM AREAS AND AWAY FROM THE INFLUENCE OF THE CONSTRUCTION. CAPTURE AND RELEASE WILL BE SUPERVISED BY A FISHERY BIOLOGIST EXPERIENCED WITH WORK AREA ISOLATION AND SAFE HANDLING OF ALL FISH.
C. ELECTROFISHING - USE ELECTROFISHING ONLY WHERE OTHER MEANS OF FISH CAPTURE MAY NOT BE FEASIBLE OR EFFECTIVE. IF ELECTROFISHING WILL BE USED TO CAPTURE FISH FOR SALVAGE, NMFS'S ELECTROFISHING GUIDELINES WILL BE FOLLOWED.

3. DEWATERING.
A. DEWATER CONSTRUCTION SITE:
1. WHEN DEWATERING IS NECESSARY TO PROTECT SPECIES OR CRITICAL HABITAT, DIVERT FLOW AROUND THE CONSTRUCTION SITE WITH A COFFER DAM (BUILT WITH NON-EROSIVE MATERIALS), TAKING CARE TO NOT DEWATER DOWNSTREAM CHANNELS DURING DEWATERING.
2. PASS FLOW AND FISH DOWNSTREAM WITH A BY-PASS CULVERT OR A DIVERSION DITCH. NATURAL FIBER SEDIMENT MATS TO BE INSTALLED AT DOWNSTREAM END OF BYPASS CHANNEL TO MINIMIZE TURBIDITY DURING INITIAL WATERING UP OF BYPASS CHANNEL.
3. DIVERSION SANDBAGS CAN BE FILLED WITH MATERIAL MINED FROM THE FLOODPLAIN AS LONG AS SUCH MATERIAL IS REPLACED AT END OF PROJECT.
4. SMALL AMOUNTS OF INSTREAM MATERIAL CAN BE MOVED TO HELP SEAL AND SECURE DIVERSION STRUCTURES.
5. IF ESA LISTED-FISH MAY BE PRESENT AND PUMPS ARE REQUIRED TO DEWATER, THE INTAKE MUST HAVE A FISH SCREEN(S) AND BE OPERATED IN ACCORDANCE WITH NMFS FISH SCREEN CRITERIA DESCRIBED BELOW (IN PART E.IV) OF THIS SECTION. DISSIPATE FLOW ENERGY AT THE BYPASS OUTFLOW TO PREVENT DAMAGE TO RIPARIAN VEGETATION OR STREAM CHANNEL.
6. IF DIVERSION ALLOWS FOR DOWNSTREAM FISH PASSAGE, PLACE DIVERSION OUTLET IN A LOCATION TO PROMOTE SAFE REENTRY OF FISH INTO THE STREAM CHANNEL, PREFERABLY INTO POOL HABITAT WITH COVER.
7. PUMP SEEPAGE WATER FROM THE DE-WATERED WORK AREA TO A TEMPORARY STORAGE AND TREATMENT SITE OR INTO UPLAND AREAS AND ALLOW WATER TO FILTER THROUGH VEGETATION PRIOR TO REENTERING THE STREAM CHANNEL.
B. SURFACE WATER MAY BE DIVERTED TO MEET CONSTRUCTION NEEDS, BUT ONLY IF DEVELOPED SOURCES ARE UNAVAILABLE OR INADEQUATE. WHERE ESA-LISTED FISH MAY BE PRESENT, DIVERSIONS MAY NOT EXCEED 10% OF THE AVAILABLE FLOW AND FISH SCREEN(S) WILL BE INSTALLED, OPERATED, AND MAINTAINED ACCORDING TO NMFS'S FISH SCREEN CRITERIA.

4. REWATERING.
A. STREAM RE-WATERING - UPON PROJECT COMPLETION, SLOWLY RE-WATER THE CONSTRUCTION SITE TO PREVENT LOSS OF SURFACE WATER DOWNSTREAM AS THE CONSTRUCTION SITE STREAMBED ABSORBS WATER AND TO PREVENT A SUDDEN RELEASE OF SUSPENDED SEDIMENT. MONITOR DOWNSTREAM DURING RE-WATERING TO PREVENT STRANDING OF AQUATIC ORGANISMS BELOW THE CONSTRUCTION SITE.

CONSTRUCTION AND POST CONSTRUCTION CONSERVATION MEASURES.

1. CONSTRUCTION AND DISCHARGE WATER.
A. ALL ACTIVITIES AUTHORIZED HEREIN THAT INVOLVE A DISCHARGE OF DREDGED OR FILL MATERIAL INTO WATERS OF THE U.S. SHALL, AT ALL TIMES, REMAIN CONSISTENT WITH ALL APPLICABLE WATER QUALITY STANDARDS, EFFLUENT LIMITATIONS AND STANDARDS OF PERFORMANCE, PROHIBITIONS, PRETREATMENT STANDARDS AND MANAGEMENT PRACTICES ESTABLISHED PURSUANT TO THE CLEAN WATER ACT (P.L. 92-500; 86 STAT. 86) OR PURSUANT TO APPLICABLE STATE AND LOCAL LAW.
B. ALL WATERS ON OKANOGAN WENATCHEE NATIONAL FOREST LANDS ARE CLASSIFIED BY THE WASHINGTON STATE DEPARTMENT OF ECOLOGY IN WAC 173-201A-200 FRESH WATER DESIGNATED USES AND CRITERIA. THE GENERAL CLASSIFICATION OF WAC 173-201A-200 CLASSIFIES ALL SURFACE WATERS ON NATIONAL FOREST SYSTEM LANDS ACCORDING TO AQUATIC LIFE USES AND ALL STREAMS WITHIN THE PROJECT AREA ARE CLASSIFIED AS CHAR SPAWNING AND REARING OR CORE SUMMER SALMONID HABITAT. WATER QUALITY STANDARDS ARE LISTED IN WAC 173-201A-200. WATER QUALITY STANDARDS ARE ESTABLISHED FOR TEMPERATURE AND TURBIDITY. THESE STANDARDS ALLOW INCREASES OVER BACKGROUND LEVELS. THE WATER QUALITY PARAMETER (WHICH HAS A WASHINGTON STATE WATER QUALITY CRITERIA) MOST LIKELY IMPACTED BY THE PROPOSED ACTIVITIES IS TURBIDITY (STREAM SEDIMENTATION). THE APPLICABLE STANDARDS FROM WAC 173-201A-200 FOR CHAR SPAWNING AND REARING OR CORE SUMMER SALMONID HABITAT STATE THAT TURBIDITY SHALL NOT EXCEED: 5 NEPHELOMETRIC TURBIDITY UNITS (NTUS) OVER BACKGROUND WHEN THE BACKGROUND IS 50 NTUS OR LESS; OR A 10 PERCENT INCREASE IN TURBIDITY WHEN THE BACKGROUND IS MORE THAN 50 NTUS.

2. TIME AND EXTENT OF DISTURBANCE.
A. TIMELY COMPLETION
1. MINIMIZE TIME IN WHICH HEAVY EQUIPMENT IS IN STREAM CHANNELS, RIPARIAN AREAS, AND WETLANDS.
2. COMPLETE EARTHWORK (INCLUDING DRILLING, EXCAVATION, DREDGING, FILLING AND COMPACTING) AS QUICKLY AS POSSIBLE.
3. DURING EXCAVATION, STOCKPILE NATIVE STREAMBED MATERIALS ABOVE THE BANK FULL ELEVATION, WHERE IT CANNOT REENTER THE STREAM, FOR LATER USE.

3. SITE RESTORATION.
A. INITIATE REHABILITATION - UPON PROJECT COMPLETION, REHABILITATE ALL DISTURBED AREAS IN A MANNER THAT RESULTS IN SIMILAR OR BETTER THAN PRE-WORK CONDITIONS THROUGH REMOVAL OF PROJECT RELATED WASTE, SPREADING OF STOCKPILED MATERIALS (SOIL, LW, TREES, ETC.) SEEDING, OR PLANTING WITH LOCAL NATIVE SEED MIXES OR PLANTS.
B. DE-COMPACT SOILS - DE-COMPACT SOIL BY SCARIFYING THE SOIL SURFACE OF ROADS AND PATHS, STREAM CROSSINGS, STAGING, AND STOCKPILE AREAS SO THAT SEEDS AND PLANTINGS CAN ROOT.
C. REMOVAL OF TEMPORARY FILLS. TEMPORARY FILLS MUST BE REMOVED IN THEIR ENTIRETY AND THE AFFECTED AREA RETURNED TO PRE-CONSTRUCTION CONTOURS.
D. STREAMBANK RESTORATION:
1. WITHOUT CHANGING THE LOCATION OF THE BANK TOE, RESTORE DAMAGED STREAMBANKS TO A NATURAL SLOPE AND PROFILE SUITABLE FOR ESTABLISHMENT OF RIPARIAN VEGETATION. THIS MAY INCLUDE SLOPING UNCONSOLIDATED BANK MATERIAL TO A STABLE ANGLE OF REPOSE OR USING BENCHES IN CONSOLIDATED, COHESIVE SOILS.
2. COMPLETE ALL SOIL REINFORCEMENT EARTHWORK AND EXCAVATION DURING DRY CONDITIONS. WHEN NECESSARY, USE SOIL LAYERS OR LIFTS STRENGTHENED WITH BIODEGRADABLE FABRICS AND PENETRABLE BY PLANT ROOTS.
3. INCLUDE LARGE WOOD TO THE EXTENT IT WOULD NATURALLY OCCUR. IF POSSIBLE, LARGE WOOD SHOULD HAVE UNTRIMMED ROOT WADS TO PROVIDE FUNCTIONAL REFUGIA HABITAT FOR FISH. WOOD ALREADY WITHIN THE STREAM OR SUSPENDED OVER THE STREAM MAY BE REPOSITIONED TO ALLOW FOR GREATER INTERACTION WITH THE STREAM.
4. ROCK WILL NOT BE USED FOR STREAMBANK RESTORATION, EXCEPT AS BALLAST TO STABILIZE LARGE WOOD.
5. USE A DIVERSE ASSEMBLAGE OF VEGETATION SPECIES NATIVE TO THE ACTION AREA, INCLUDING TREES, SHRUBS, AND HERBACEOUS SPECIES. VEGETATION, SUCH AS WILLOW, SEDGE, AND RUSH MATS, MAY BE GATHERED FROM LOCAL SOURCES (FOR EXAMPLE, WITHIN THE SEED ZONE AREA), INCLUDING ABANDONED FLOODPLAINS, STREAM CHANNELS, ETC.
6. DO NOT APPLY SURFACE FERTILIZER WITHIN 50 FEET OF ANY STREAM CHANNEL.
7. INSTALL FENCING AS NECESSARY TO PREVENT ACCESS TO REVEGETATED SITES BY LIVESTOCK OR UNAUTHORIZED PERSONS.
8. CONDUCT POST-CONSTRUCTION MONITORING AND TREATMENT OR REMOVAL OF INVASIVE PLANTS UNTIL NATIVE PLANT SPECIES ARE WELL ESTABLISHED.
E. OFF-AND-SIDE-CHANNEL HABITAT RESTORATION
1. NATIONAL MARINE FISHERIES SERVICE HYDRO FISH PASSAGE REVIEW AND APPROVAL - WHEN A PROPOSED SIDE CHANNEL WILL CONTAIN MORE THAN 20 PERCENT OF THE BANKFULL FLOW, NATIONAL FOREST OR SCENIC AREA PERSONNEL WILL ENSURE THE ACTION IS INDIVIDUALLY REVIEWED BY THE PORTLAND OFFICE OF THE NATIONAL MARINE FISHERIES SERVICE HABITAT CONSERVATION DIVISION FOR CONSISTENCY WITH CRITERIA IN NATIONAL MARINE FISHERIES SERVICE
2. DATA REQUIREMENTS - DATA REQUIREMENTS AND ANALYSIS FOR OFF- AND SIDE-CHANNEL HABITAT RESTORATION INCLUDE EVIDENCE OF HISTORICAL CHANNEL LOCATION, SUCH AS LAND USE SURVEYS, HISTORICAL PHOTOGRAPHS, TOPOGRAPHIC MAPS, REMOTE SENSING INFORMATION, OR PERSONAL OBSERVATION.

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PLAN SHEET SIZE ANSI B (11" X 17")

REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK PALS DESIGN

CONSERVATION MEASURES

DWG. NO.: G-004
CREATED: 11/30/2022
SHEET: 4 of 20

D:\Z\PROJECTS\194-1359-0002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\01_COVER PAGE AND NOTES.DWG
PLOT DETAILS: HARVEY, SPENCER November 30, 2022 4:39 PM

CONSTRUCTION AND POST CONSTRUCTION CONSERVATION MEASURES (CONTINUED).

3. ALLOWABLE EXCAVATION - OFF- AND SIDE-CHANNEL IMPROVEMENTS CAN INCLUDE MINOR EXCAVATION (10 PERCENT OR LESS OF VOLUME) OF NATURALLY ACCUMULATED SEDIMENT WITHIN HISTORICAL CHANNELS. THERE IS NO LIMIT TO THE AMOUNT OF EXCAVATION OF HUMAN-CREATED FILL WITHIN HISTORICAL SIDE CHANNELS AS LONG AS SUCH CHANNELS CAN BE CLEARLY IDENTIFIED THROUGH FIELD PHOTOGRAPHS, AERIAL PHOTOGRAPHS, OR BOTH. EXCAVATION DEPTH WILL NOT EXCEED THE MAXIMUM THALWEG DEPTH IN THE MAIN CHANNEL. EXCAVATED MATERIAL REMOVED FROM OFF- OR SIDE-CHANNELS SHALL BE HAULED TO AN UPLAND SITE OR SPREAD ACROSS THE ADJACENT FLOODPLAIN IN A MANNER THAT DOES NOT RESTRICT FLOODPLAIN CAPACITY.

F. SET-BACK OR REMOVAL OF EXISTING BERMS, DIKES, AND LEVEES
1. DESIGN ACTIONS TO RESTORE FLOODPLAIN CHARACTERISTICS--ELEVATION, WIDTH, GRADIENT, LENGTH, AND ROUGHNESS--IN A MANNER THAT CLOSELY MIMICS, TO THE EXTENT POSSIBLE, THOSE THAT WOULD NATURALLY OCCUR AT THAT STREAM AND VALLEY TYPE.
2. TO THE EXTENT POSSIBLE, REMOVE NONNATIVE FILL MATERIAL FROM THE FLOODPLAIN TO AN UPLAND SITE.
3. WHERE IT IS NOT POSSIBLE TO REMOVE OR SET-BACK ALL PORTIONS OF DIKES AND BERMS, OR IN AREAS WHERE EXISTING BERMS, DIKES, AND LEVEES SUPPORT ABUNDANT RIPARIAN VEGETATION, OPENINGS WILL BE CREATED WITH BREACHES. BREACHES SHALL BE EQUAL TO, OR GREATER THAN, THE ACTIVE CHANNEL WIDTH TO REDUCE THE POTENTIAL FOR CHANNEL AVULSION DURING FLOOD EVENTS. IN ADDITION TO OTHER BREACHES, THE BERM, DIKE, OR LEVEE SHALL ALWAYS BE BREACHED AT THE DOWNSTREAM END OF THE PROJECT, AT THE LOWEST ELEVATION OF THE FLOODPLAIN, OR BOTH TO ENSURE THE FLOWS WILL NATURALLY RECEDE BACK INTO THE MAIN CHANNEL THUS MINIMIZING FISH ENTRAPMENT.
4. ELEVATIONS OF DIKE AND LEVEE SETBACKS SHALL NOT EXCEED THE ELEVATION OF REMOVED STRUCTURES.
5. WHEN NECESSARY, LOOSEN COMPACTED SOILS ONCE OVERBURDEN MATERIAL IS REMOVED. OVERBURDEN OR FILL COMPRISED OF NATIVE MATERIALS FROM THE PROJECT AREA MAY BE USED WITHIN THE FLOODPLAIN TO CREATE SET-BACK DIKES AND FILL HUMAN-CAUSED HOLES PROVIDED FLOODPLAIN FUNCTION IS NOT IMPEDED.

4. MATERIAL PLACEMENT AND DISPOSAL

A. USE AND DISPOSAL OF EXCESS MATERIAL.
1. ALL CONSTRUCTION DEBRIS AND ANY OTHER MATERIAL NOT AUTHORIZED BY THE CORPS FOR PERMANENT PLACEMENT INTO WATERS OF THE UNITED STATES SHALL BE DISPOSED OF IN AN UPLAND LOCATION IN A MANNER THAT PRECLUDES IT FROM ENTERING WATERS OF THE UNITED STATES.
2. GRAVEL CAN BE PLACED DIRECTLY INTO THE STREAM CHANNEL, AT TRIBUTARY JUNCTIONS, OR OTHER AREAS IN A MANNER THAT MIMICS NATURAL DEBRIS FLOWS AND EROSION.
3. AUGMENTATION WILL ONLY OCCUR IN AREAS WHERE THE NATURAL SUPPLY HAS BEEN ELIMINATED, SIGNIFICANTLY REDUCED THROUGH ANTHROPOGENIC DISRUPTIONS, OR USED TO INITIATE GRAVEL ACCUMULATIONS IN CONJUNCTION WITH OTHER PROJECTS, SUCH AS SIMULATED LOG JAMS AND DEBRIS FLOWS.
4. GRAVEL TO BE PLACED IN STREAMS SHALL BE A PROPERLY SIZED GRADATION FOR THAT STREAM, CLEAN, AND NON-ANGULAR.
5. WHEN POSSIBLE, USE GRAVEL OF THE SAME LITHOLOGY AS FOUND IN THE WATERSHED. REFERENCE THE STREAM SIMULATION: AN ECOLOGICAL APPROACH TO PROVIDING PASSAGE FOR AQUATIC ORGANISMS AT ROAD-STREAM CROSSINGS (USDA-FOREST SERVICE 2008) TO DETERMINE GRAVEL SIZES APPROPRIATE FOR THE STREAM.
6. GRAVEL CAN BE MINED FROM THE FLOODPLAIN AT ELEVATIONS ABOVE BANK-FULL, BUT NOT IN A MANNER THAT WOULD CAUSE STRANDING DURING FUTURE FLOOD EVENTS.
7. CRUSHED ROCK IS NOT PERMITTED. AFTER GRAVEL PLACEMENT IN AREAS ACCESSIBLE TO HIGHER STREAM FLOW, ALLOW THE STREAM TO NATURALLY SORT AND DISTRIBUTE THE MATERIAL.
8. DO NOT PLACE GRAVEL DIRECTLY ON BARS AND RIFFLES THAT ARE KNOWN SPAWNING AREAS, WHICH MAY CAUSE FISH TO SPAWN ON THE UNSORTED AND UNSTABLE GRAVEL, THUS POTENTIALLY RESULTING IN REDD DESTRUCTION. IMPORTED GRAVEL MUST BE FREE OF INVASIVE SPECIES AND NON-NATIVE SEEDS. IF NECESSARY, WASH GRAVEL PRIOR TO PLACEMENT.

5. REVEGETATION.

A. THE PERMITTEE MUST REVEGETATE DISTURBED AREAS WITH NATIVE PLANT SPECIES SUFFICIENT IN NUMBER, SPACING, AND DIVERSITY TO RESTORE AFFECTED FUNCTIONS. A MAINTENANCE AND MONITORING PLAN COMMENSURATE WITH THE IMPACTS, MAY BE REQUIRED. REVEGETATION MUST BEGIN AS SOON AS SITE CONDITIONS ALLOW WITHIN THE SAME GROWING SEASON AS THE DISTURBANCE UNLESS THE SCHEDULE IS APPROVED BY THE CORPS OF ENGINEERS.

B. NATIVE PLANTS REMOVED FROM WATERS OF THE U.S. FOR PROJECT CONSTRUCTION SHOULD BE STOCKPILED AND USED FOR REVEGETATION WHEN FEASIBLE.

C. TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES MUST BE REMOVED AS SOON AS THE AREA HAS ESTABLISHED VEGETATION SUFFICIENT TO CONTROL EROSION AND SEDIMENT.
1. NATURAL FIBER EROSION CONTROL MATERIALS ARE RECOMMENDED FOR SHORT TERM EROSION CONTROL.
2. WHERE PERMANENT EROSION CONTROL/PLANTING MATTING IS REQUIRED, MATERIALS MUST BE NATURAL FIBER COMPOSITION ONLY (NO PLASTICS/SYNTHETIC MATERIAL).

D. REPLANT EACH AREA REQUIRING REVEGETATION PRIOR TO OR AT THE BEGINNING OF THE FIRST GROWING SEASON FOLLOWING CONSTRUCTION.
1. ACHIEVE RE-ESTABLISHMENT OF VEGETATION IN DISTURBED AREAS TO AT LEAST 70% OF PRE-PROJECT LEVELS WITHIN THREE YEARS.
2. USE AN APPROPRIATE MIX OF SPECIES THAT WILL ACHIEVE ESTABLISHMENT AND EROSION CONTROL OBJECTIVES, PREFERABLY FORB, GRASS, SHRUB, OR TREE SPECIES NATIVE TO THE PROJECT AREA OR REGION AND APPROPRIATE TO THE SITE. BARRIERS WILL BE INSTALLED AS NECESSARY TO PREVENT ACCESS TO REVEGETATED SITES BY LIVESTOCK OR UNAUTHORIZED PERSONS

E. ALL RIPARIAN PLANTINGS SHALL FOLLOW FOREST SERVICE DIRECTION DESCRIBED IN THE REGIONAL LETTER TO UNITS, USE OF NATIVE AND NONNATIVE PLANTS ON NATIONAL FORESTS AND GRASSLANDS MAY 2006 (FINAL DRAFT), AND OR BLM INSTRUCTION MEMORANDUM NO. OR-2001-014, POLICY ON THE USE OF NATIVE SPECIES PLANT MATERIAL.

6. TREE REMOVAL

A. HAZARD TREES - WHERE APPROPRIATE, INCLUDE HAZARD TREE REMOVAL (AMOUNT AND TYPE) IN PROJECT DESIGN.
1. FELL HAZARD TREES WHEN THEY POSE A SAFETY RISK.
2. IF POSSIBLE, FELL HAZARD TREES WITHIN RIPARIAN AREAS TOWARDS A STREAM.
3. KEEP FELLED TREES ON SITE WHEN NEEDED TO MEET COARSE LW OBJECTIVES.

B. LIVE CONIFERS AND OTHER TREES CAN BE FELLED OR PULLED/PUSHED OVER IN A NORTHWEST FOREST PLAN, RIPARIAN RESERVE, OR PACFISH/INFISH RIPARIAN HABITAT CONSERVATION AREAS, AND UPLAND AREAS (E.G., LATE SUCCESSIONAL RESERVES OR ADAPTIVE MANAGEMENT AREAS FOR NORTHERN SPOTTED OWL AND MARBLED MURRELET CRITICAL HABITAT) FOR IN-CHANNEL LW PLACEMENT ONLY WHEN CONIFERS AND TREES ARE FULLY STOCKED.

C. TREE FELLING SHALL NOT CREATE EXCESSIVE STREAM BANK EROSION OR INCREASE THE LIKELIHOOD OF CHANNEL AVULSION DURING HIGH FLOWS.

D. DANGER TREES AND TREES KILLED THROUGH FIRE, INSECTS, DISEASE, BLOW-DOWN AND OTHER MEANS CAN BE FELLED AND USED FOR IN-CHANNEL PLACEMENT REGARDLESS OF LIVE-TREE STOCKING LEVELS.

E. TREES MAY BE REMOVED BY CABLE, GROUND-BASED EQUIPMENT, HORSES OR HELICOPTERS.

F. TREES MAY BE FELLED OR PUSHED/PULLED DIRECTLY INTO A STREAM OR FLOODPLAIN.

G. TREES MAY BE STOCKPILED AT DESIGNATED STAGING AREAS.

H. IDENTIFIED TREES ARE MARKED, AND WILL MEET THE DESIGN CRITERIA, THE CONTRACTOR WILL DO ITS BEST TO STICK TO IDENTIFIED SKID TRAILS AND MINIMIZE SURROUNDING TREE DAMAGE WHEN FELLING THE TREES.

I. DURING ROOT-WAD REMOVAL, MINIMIZE SOIL DISTURBANCE.
1. USFS WILL DETERMINE WHEN SOIL MOISTURE IS CONDUCIVE TO MINIMIZE SOIL DISTURBANCE DURING ROOTWAD HARVEST. SOIL CONDITIONS ARE NOT EXPECTED TO BE APPROPRIATE UNTIL JUNE 1.
2. ONLY EXCAVATE THE AREA NECESSARY FOR REMOVAL AROUND THE ROOTS.
3. IF PULLING THE ROOT WAD WITH A FELLER-BUNCHER, CARE SHALL BE EXERCISED TO LIMIT SOIL DETACHMENT.
4. POST REMOVAL, SHAKE THE TREE TO MINIMIZE OFF-SITE SOIL LOSS. RETURN THE AREA TO THE PRE-DISTURBANCE TOPOGRAPHY, IF NEEDED, WITH HAND TOOLS.
5. DURING THE PROCESS, CARE SHALL BE TAKEN TO NOT COMPACT THE AREA WHERE THE ROOT WAD WAS HARVESTED.
6. DO NOT DISTURB OR COMPACT THE SURROUNDING SOIL. RETAIN OR ENHANCE GROUND COVER WHERE POSSIBLE.

J. TO PROTECT AGAINST SOIL DISPLACEMENT, PARTIAL SUSPENSION WHILE YARDING THROUGH THE HARVEST AREA IS REQUIRED.

K. ALL DISTURBED AREAS MUST BE RESTORED TO MEET WFP COVER REQUIREMENTS. THIS INCLUDES THE PLACEMENT OF SLASH AND SEEDING OF MAJOR SKID TRAILS, LANDINGS, AND TEMPORARY ROADS. ROOT WAD HARVESTED AREAS MUST BE RESTORED WITH SEEDING, MULCHING, OR SLASH COVER

L. IN TIMBER HARVEST AREAS, MECHANICAL DECOMPACTION (RIPPING, SUBSOILING, ETC.) WOULD OCCUR WITHIN RIPARIAN RESERVES ONLY WHEN DETERMINED TO BE BENEFICIAL BY A HYDROLOGIST OR SOIL SCIENTIST.

M. OUTSIDE OF RIPARIAN RESERVES, MECHANICAL DECOMPACTION IS REQUIRED ON LANDINGS, MAJOR SKID TRAILS AND TEMPORARY ROADS. SEEDING AND SLASH COVER IS ALSO REQUIRED IN THESE AREAS

N. NO TIMBER HARVEST ACTIVITIES SHALL OCCUR ON SLOPES EXCEEDING 30% WITHOUT THE AUTHORIZATION OF THE DISTRICT SOIL SCIENTIST OR HYDROLOGIST

O. A WILDLIFE BIOLOGIST MUST BE FULLY INVOLVED IN ALL TREE-REMOVAL PLANNING EFFORTS AND BE INVOLVED IN MAKING DECISIONS ON WHETHER INDIVIDUAL TREES ARE SUITABLE FOR NESTING OR HAVE OTHER IMPORTANT LISTED BIRD HABITAT VALUE.

P. TREES CAN BE REMOVED TO A LEVEL NOT LESS THAN A RELATIVE DENSITY OF APPROXIMATELY 35, WHICH IS CONSIDERED AS FULLY OCCUPYING A SITE. THIS EQUATES TO APPROXIMATELY 60 TREES PER ACRE IN THE OVERSTORY AND A TREE SPACING AVERAGING 26 FEET. ADDITIONALLY, 40 PERCENT CANOPY COVER WOULD BE MAINTAINED IN NORTHERN SPOTTED OWL OR MARBLED MURRELET CRITICAL HABITAT WITHIN 300 FEET OF OCCUPIED OR UNSURVEY MURRELET NESTING STRUCTURE AND WHEN DISPERSAL HABITAT IS LIMITED IN THE AREA.

Q. THE PROJECT MANAGER FOR AN AQUATIC RESTORATION ACTION PLANNED UNDER THIS PROJECT ENVIRONMENTAL ASSESSMENT WILL COORDINATE WITH AN ACTION-AGENCY WILDLIFE BIOLOGIST IN TREE- REMOVAL PLANNING EFFORTS.

R. IN NORTHERN SPOTTED OWL AND MARBLED MURRELET HABITAT, MEET THE FOLLOWING REQUIREMENTS: THE FOLLOWING PROJECT DESIGN CRITERIA APPLIES TO TREE REMOVAL WITHIN THE RANGE OF MARBLED MURRELETS AND THE NORTHERN SPOTTED OWL IN DOUGLAS-FIR DOMINATED STANDS LESS THAN 80 YEARS OLD THAT ARE NOT FUNCTIONING AS FORAGING HABITAT WITHIN A SPOTTED OWL HOME RANGE NOR DO THEY CONTAIN MURRELET NESTING STRUCTURE. IT DOES NOT APPLY TO TREE SELECTION IN OLDER STANDS OR HARDWOOD-DOMINATED STANDS UNLESS STATED OTHERWISE. THE PURPOSE OF THESE CRITERIA IS TO ENSURE THERE WOULD BE NO REMOVAL OR ADVERSE MODIFICATION OF SUITABLE HABITAT FOR MARBLED MURRELET OR NORTHERN SPOTTED OWL.
1. A WILDLIFE BIOLOGIST MUST BE FULLY INVOLVED IN ALL TREE-REMOVAL PLANNING EFFORTS AND BE INVOLVED IN MAKING DECISIONS ON WHETHER INDIVIDUAL TREES ARE SUITABLE FOR NESTING OR HAVE OTHER IMPORTANT LISTED BIRD HABITAT VALUE.
2. TREES CAN BE REMOVED TO A LEVEL NOT LESS THAN A RELATIVE DENSITY OF APPROXIMATELY 35, WHICH IS CONSIDERED AS FULLY OCCUPYING A SITE.
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1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK PALS DESIGN

CONSERVATION MEASURES

DWG. NO.: G-005

CREATED: 11/30/2022

CONSTRUCTION AND POST CONSTRUCTION CONSERVATION MEASURES (CONTINUED).

4. ADDITIONALLY 40 PERCENT CANOPY COVER WOULD BE MAINTAINED IN NORTHERN SPOTTED OWL OR MARBLED MURRELET CRITICAL HABITAT WITHIN 300 FEET OF OCCUPIED OR UNSURVEYED MURRELET NESTING STRUCTURE AND WHEN DISPERSAL HABITAT IS LIMITED IN THE AREA.TREES TO BE REMOVED CAN BE LIVE, HAZARD TREES OR TREES KILLED THROUGH FIRE, INSECTS, DISEASE, BLOWDOWN, AND OTHER MEANS. DOWN TREES AND SNAGS SHOULD ONLY BE REMOVED IF THE STAND WILL RETAIN NORTHWEST FOREST PLAN STANDARDS POST REMOVAL.
5. TREES MAY BE REMOVED BY CABLE, GROUND-BASED EQUIPMENT, HORSES, OR HELICOPTERS. THEY MAY BE FELLED OR PUSHED OR PULLED DIRECTLY INTO A STREAM. TREES MAY BE STOCKPILED FOR FUTURE INSTREAM RESTORATION PROJECTS.
6. TREE SPECIES REMOVED SHOULD BE RELATIVELY COMMON IN THE STAND (NOT MINOR TREE SPECIES).
7. SNAGS AND TREES WITH BROAD, DEEP CROWNS ("WOLF" TREES), DAMAGED TOPS OR OTHER ABNORMALITIES THAT MAY PROVIDE A VALUABLE WILDLIFE HABITAT COMPONENT SHOULD BE RESERVED.
8. NO GAPS (OPENINGS) GREATER THAN 0.5 ACRE WILL BE CREATED IN SPOTTED OWL CRITICAL HABITAT. NO GAPS GREATER THAN ¼ ACRE WILL BE CREATED IN MURRELET CRITICAL HABITAT. NO GAPS SHALL BE CREATED IN RIPARIAN RESERVES THAT CONTAIN FEDERALLY LISTED FISH HABITAT.

7. ENGINEERED LOG JAM (ELJ) DESIGN

A. FOR ELJS THAT OCCUPY >25% OF THE BANKFULL AREA, THE ACTION AGENCIES WILL ENSURE THAT THE ACTION IS INDIVIDUALLY REVIEWED AND APPROVED BY NMFS FOR CONSISTENCY WITH CRITERIA IN *ANADROMOUS SALMONID PASSAGE FACILITY DESIGN.*
B. ELJS WILL BE PATTERNED, TO THE GREATEST DEGREE POSSIBLE, AFTER STABLE NATURAL LOG JAMS.
C. GRADE CONTROL ELJS ARE DESIGNED TO ARREST CHANNEL DOWN-CUTTING OR INCISION BY PROVIDING A GRADE CONTROL THAT RETAINS SEDIMENT, LOWERS STREAM ENERGY, AND INCREASES WATER ELEVATIONS TO RECONNECT FLOODPLAIN HABITAT AND DIFFUSE DOWNSTREAM FLOOD PEAKS.
D. STABILIZING OR KEY PIECES OF LW THAT WILL BE RELIED ON TO PROVIDE STREAMBANK STABILITY OR REDIRECT FLOWS MUST BE INTACT, SOLID (LITTLE DECAY). IF POSSIBLE, ACQUIRE LW WITH UNTRIMMED ROOTWADS TO PROVIDE FUNCTIONAL REFUGIA HABITAT FOR FISH.
E. WHEN AVAILABLE, TREES WITH ROOTWADS ATTACHED SHOULD BE A MINIMUM LENGTH OF 1.5 TIMES THE BANKFULL CHANNEL WIDTH, WHILE LOGS WITHOUT ROOTWADS SHOULD BE A MINIMUM OF 2.0 TIMES THE BANKFULL WIDTH.
F. THE PARTIAL BURIAL OF LW AND BOULDERS MAY CONSTITUTE THE DOMINANT MEANS OF PLACEMENT, AND KEY BOULDERS (FOOTINGS) OR LW CAN BE BURIED INTO THE STREAM BANK OR CHANNEL
G. ANGLE AND OFFSET - THE LW PORTIONS OF ENGINEERED LOG JAM STRUCTURES SHOULD BE ORIENTED SUCH THAT THE FORCE OF WATER UPON THE LW INCREASES STABILITY. IF A ROOTWAD IS LEFT EXPOSED TO THE FLOW, THE BOLE PLACED INTO THE STREAMBANK SHOULD BE ORIENTED DOWNSTREAM PARALLEL TO THE FLOW DIRECTION SO THE PRESSURE ON THE ROOTWAD PUSHES THE BOLE INTO THE STREAMBANK AND BED. WOOD MEMBERS THAT ARE ORIENTED PARALLEL TO FLOW ARE MORE STABLE THAN MEMBERS ORIENTED AT 45 OR 90 DEGREES TO THE FLOW.
H. IF LW ANCHORING IS REQUIRED, A VARIETY OF METHODS MAY BE USED. THESE INCLUDE BUTTRESSING THE WOOD BETWEEN RIPARIAN TREES, THE USE OF MANILA, SISAL OR OTHER BIODEGRADABLE ROPES FOR LASHING CONNECTIONS. IF HYDRAULIC CONDITIONS WARRANT USE OF STRUCTURAL CONNECTIONS, SUCH AS REBAR PINNING OR BOLTED CONNECTIONS, MAY BE USED. ROCK MAY BE USED FOR BALLAST BUT IS LIMITED TO THAT NEEDED TO ANCHOR THE LW.
I. STRUCTURE TYPES SHALL SIMULATE DISTURBANCE EVENTS TO THE GREATEST DEGREE POSSIBLE AND INCLUDE, BUT ARE NOT LIMITED TO, LOG JAMS, DEBRIS FLOWS, WIND-THROW, AND TREE BREAKAGE.
J. PROJECTS CAN INCLUDE GRADE CONTROL AND BANK STABILIZATION STRUCTURES, WHILE SIZE AND CONFIGURATION OF SUCH STRUCTURES WILL BE COMMENSURATE WITH SCALE OF PROJECT SITE AND HYDRAULIC FORCES.
K. PLACE LARGE WOOD AND BOULDERS IN AREAS WHERE THEY WOULD NATURALLY OCCUR AND IN A MANNER CONSISTENT WITH CHANNEL, VALLEY, AND FOREST TYPE. FOR EXAMPLE, BOULDER PLACEMENT MAY NOT BE APPROPRIATE IN LOW-GRADIENT MEADOW STREAMS.
L. THE SIZE OR SHAPE OF LARGE WOOD AND BOULDER STRUCTURES MUST BE WITHIN THE RANGE OF NATURAL VARIABILITY OF A GIVEN LOCATION AND SHOULD NOT BLOCK PASSAGE OF FISH AND OTHER AQUATIC ORGANISMS.
M. THE PARTIAL BURIAL OF LARGE WOOD AND BOULDERS IS PERMITTED AND MAY CONSTITUTE THE DOMINANT MEANS OF PLACEMENT. THIS APPLIES TO ALL STREAM SYSTEMS BUT MORE SO FOR LARGER STREAM SYSTEMS WHERE USE OF ADJACENT RIPARIAN TREES OR CHANNEL FEATURES IS NOT FEASIBLE OR DOES NOT PROVIDE THE FULL STABILITY DESIRED.
N. LARGE WOOD INCLUDES WHOLE CONIFER AND HARDWOOD TREES, LOGS, AND ROOTWADS. LARGE WOOD SIZE (DIAMETER AND LENGTH) SHOULD ACCOUNT FOR BANKFULL WIDTH AND STREAM DISCHARGE RATES. WHEN AVAILABLE, TREES WITH ROOTWADS SHOULD BE A MINIMUM OF 1.5 TIMES BANKFULL CHANNEL WIDTH, WHILE LOGS WITHOUT ROOTWADS SHOULD BE A MINIMUM OF 2.0 TIMES BANKFULL WIDTH.
O. STRUCTURES MAY PARTIALLY OR COMPLETELY SPAN STREAM CHANNELS OR BE POSITIONED ALONG STREAM BANKS.
P. STABILIZING OR KEY PIECES OF LARGE WOOD MUST BE INTACT, HARD, WITH LITTLE DECAY, AND IF POSSIBLE HAVE ROOT WADS (UNTRIMMED) TO PROVIDE FUNCTIONAL REFUGIA HABITAT FOR FISH. CONSIDER ORIENTING KEY PIECES SUCH THAT THE HYDRAULIC FORCES UPON THE LARGE WOOD INCREASES STABILITY.
Q. ANCHORING LARGE WOOD - ANCHORING ALTERNATIVES MAY BE USED IN PREFERENTIAL ORDER:
   1. USE OF ADEQUATE SIZED WOOD SUFFICIENT FOR STABILITY
   2. ORIENT AND PLACE WOOD IN SUCH A WAY THAT MOVEMENT IS LIMITED
   3. BALLAST (GRAVEL, ROCK, OR BOTH) TO INCREASE THE MASS OF THE STRUCTURE TO RESIST MOVEMENT
   4. USE OF LARGE BOULDERS AS ANCHOR POINTS FOR THE LARGE WOOD
   5. PIN LARGE WOOD WITH REBAR TO LARGE ROCKS TO INCREASE ITS WEIGHT. FOR STREAMS THAT ARE ENTRENCHED (ROSGEN F, G, A, AND POTENTIALLY B) OR FOR OTHER STREAMS WITH VERY LOW WIDTH- TO-DEPTH RATIOS (LESS THAN 12), AN ADDITIONAL 60 PERCENT BALLAST WEIGHT MAY BE NECESSARY DUE TO GREATER FLOW DEPTHS AND HIGHER VELOCITIES.

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WALLA WALLA COUNTY CONSERVATION DISTRICT
ESTABLISHED 1941

NOT FOR CONSTRUCTION

PLAN SHEET SIZE ANSI B (11" X 17")

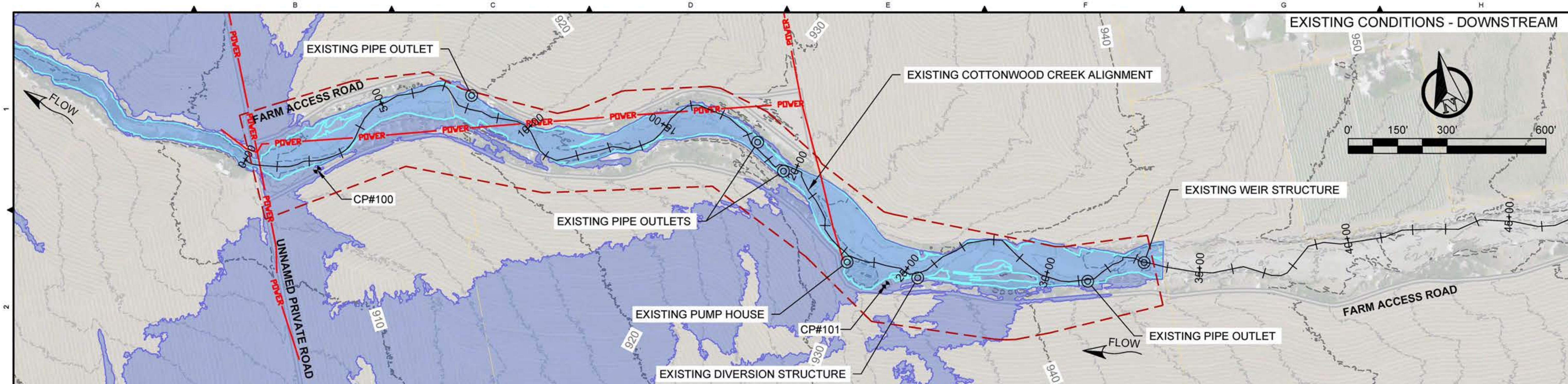
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK PALS DESIGN

CONSERVATION MEASURES

DWG. NO.: G-006

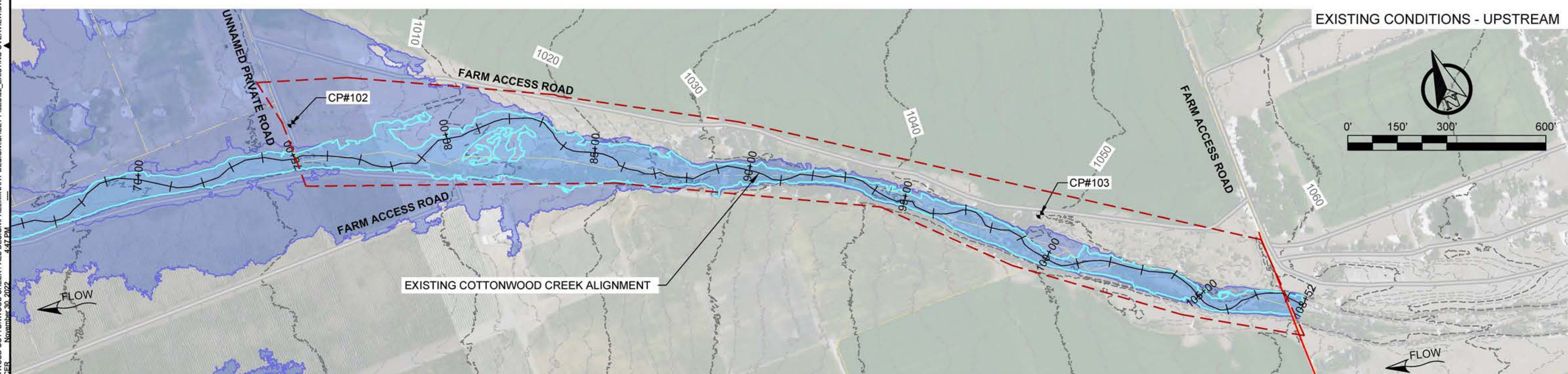
CREATED: 11/30/2022



LEGEND:

- 2' EXISTING CONTOUR
- 10' EXISTING CONTOUR
- EXISTING ALIGNMENT
- EXISTING POWERLINE
- EXISTING ROAD
- PROPERTY BOUNDARY
- EXISTING 100-YEAR WSE
- EXISTING 2-YEAR WSE
- PROJECT BOUNDARY
- SURVEYED CONTROL POINT

COTTONWOOD CREEK CONTROL POINTS				
POINT #	NORTHING	EASTING	ELEVATION	DESCRIPTION
100	258358.42	2190334.32	914.90	CP
101	257715.46	2191973.59	937.46	CP
102	257653.45	2196786.80	1002.28	CP
103	256618.69	2198824.59	1049.71	CP



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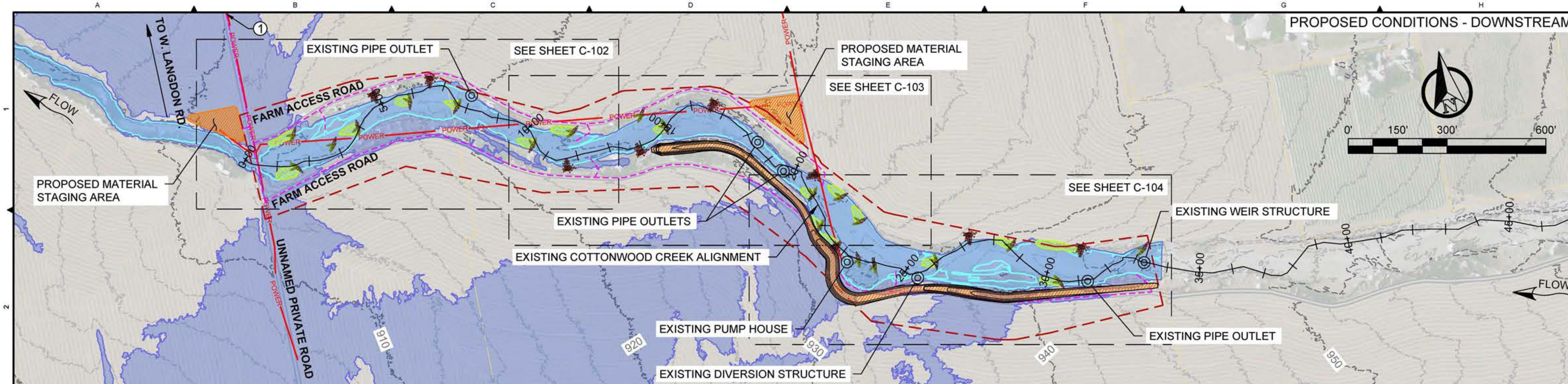
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK
PALS DESIGN

GENERAL OVERVIEW
EXISTING CONDITIONS

DWG. NO.: E-101
CREATED: 11/30/2022
SHEET: 7 of 20

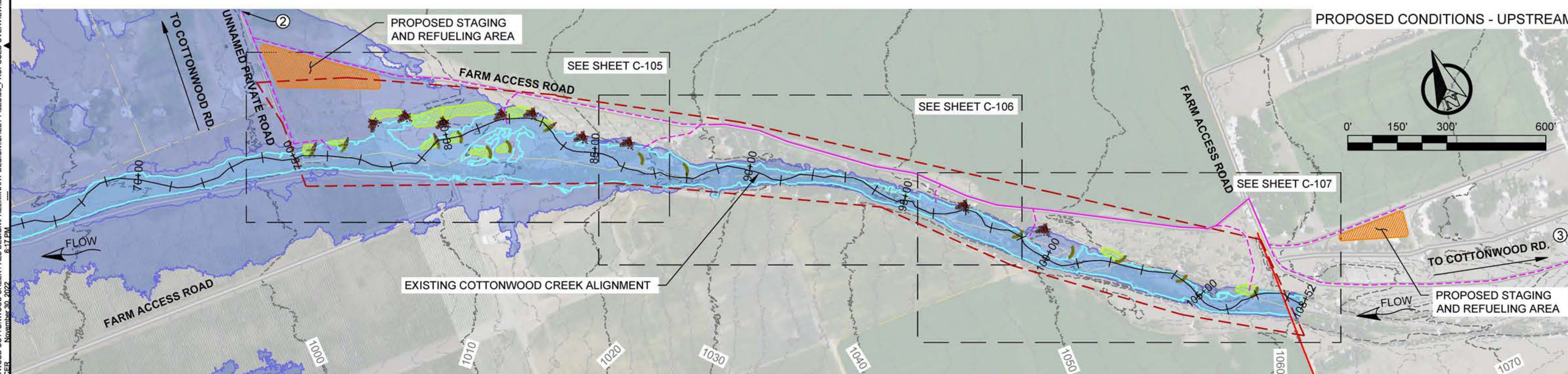


LEGEND:

- 2' EXISTING CONTOUR
- 10' EXISTING CONTOUR
- EXISTING ALIGNMENT
- EXISTING POWERLINE
- EXISTING ROAD
- PROPERTY BOUNDARY
- PROPOSED ACCESS ROUTE
- 2' PROPOSED CONTOUR
- 10' PROPOSED CONTOUR
- EXISTING 100-YEAR WSE
- EXISTING 2-YEAR WSE
- PROJECT BOUNDARY
- PROPOSED BERM
- PROPOSED RIPARIAN PLANTING
- PROPOSED STAGING AREA
- SHEET BOUNDARY
- PROPOSED HABITAT FEATURE

NOTES:

1. DOWNSTREAM SITE ACCESS VIA W. LANGDON RD. FROM THE WEST, THEN AT 0.5 MILES HEAD SOUTH (TURN AT S. 3RD AVE.) ON AN UNNAMED PRIVATE ROAD.
2. UPSTREAM SITE ACCESS VIA COTTONWOOD RD. FROM THE NORTH, THEN AT 1.5 MILES HEAD SOUTH (TURN AT KENDALL RD.) ON AN UNNAMED PRIVATE ROAD.
3. UPSTREAM SITE ACCESS VIA COTTONWOOD RD. FROM THE NORTH, THEN AT 2.25 MILES HEAD SOUTH ON AN UNNAMED PRIVATE ROAD.



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PLAN SHEET SIZE ANSI B (11" X 17")

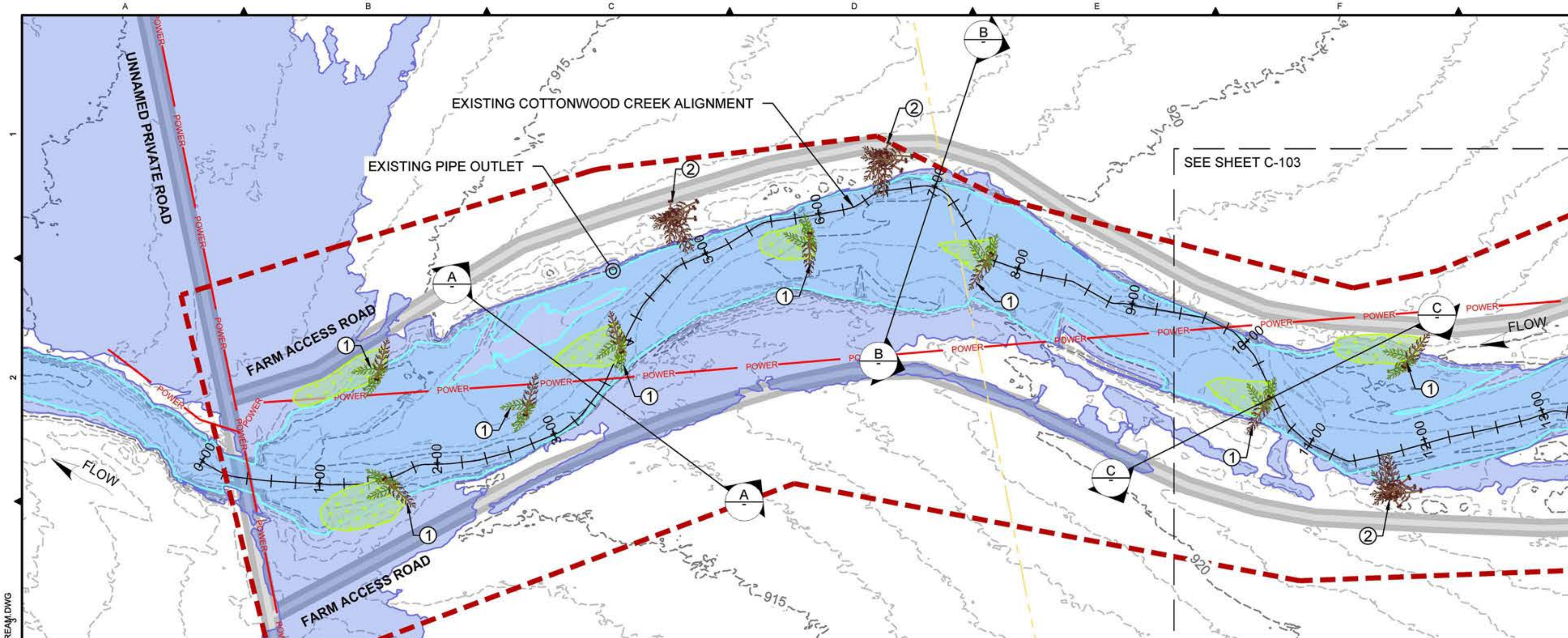
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK
PALS DESIGN

GENERAL OVERVIEW
PROPOSED CONDITIONS

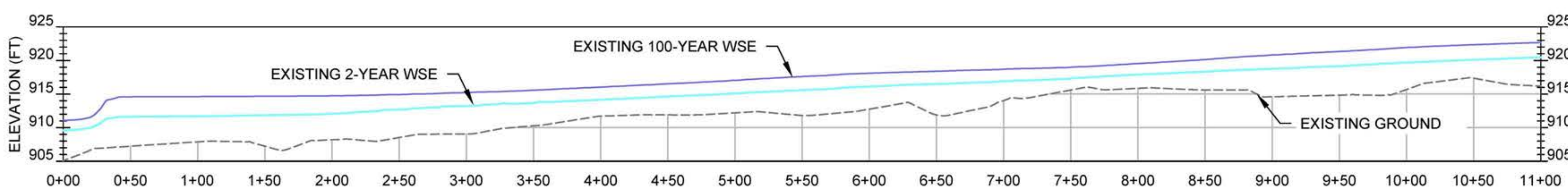
DWG. NO.: C-101
CREATED: 11/30/2022
SHEET: 8 of 20

D:\Z\PROJECTS\194-1359-0002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\03_PROPOSED OVERVIEW.DWG
PLOT DETAILS: HARVEY, SPENCER November 30, 2022 8:17 PM



LEGEND:

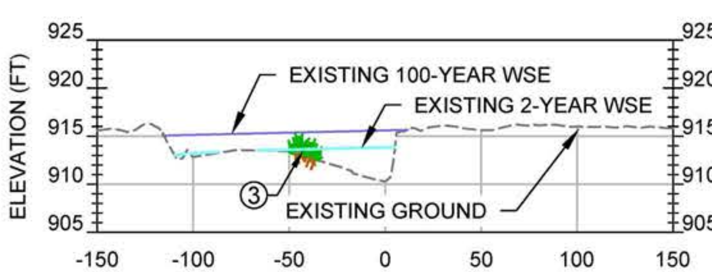
- 1' EXISTING CONTOUR
- 5' EXISTING CONTOUR
- EXISTING ALIGNMENT
- EXISTING POWERLINE
- EXISTING ROAD
- PROPERTY BOUNDARY
- EXISTING 100-YEAR WSE
- EXISTING 2-YEAR WSE
- PROJECT BOUNDARY
- PROPOSED RIPARIAN PLANTING
- SHEET BOUNDARY
- PROPOSED HABITAT FEATURE



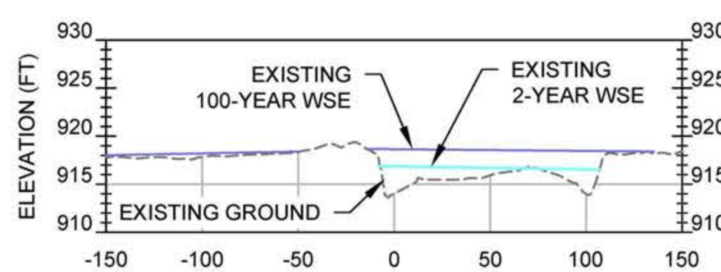
COTTONWOOD CREEK ALIGNMENT PROFILE STA 0+00 TO STA 11+00 (FT)
(SCALE 1" = 100', 1H:5V)

NOTES:

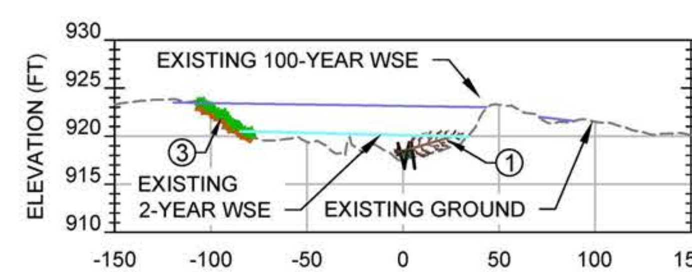
1. PROPOSED BANK ATTACHED PALS HABITAT FEATURE. SEE SHEET C-109 FOR DETAILS.
2. PROPOSED BANK HABITAT STRUCTURE. SEE SHEET C-110 FOR DETAILS.
3. PROPOSED RIPARIAN PLANTING. SEE SHEET L-101 FOR DETAILS.



A - PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



B - PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



C - PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V

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PLAN SHEET SIZE ANSI B (11" X 17")

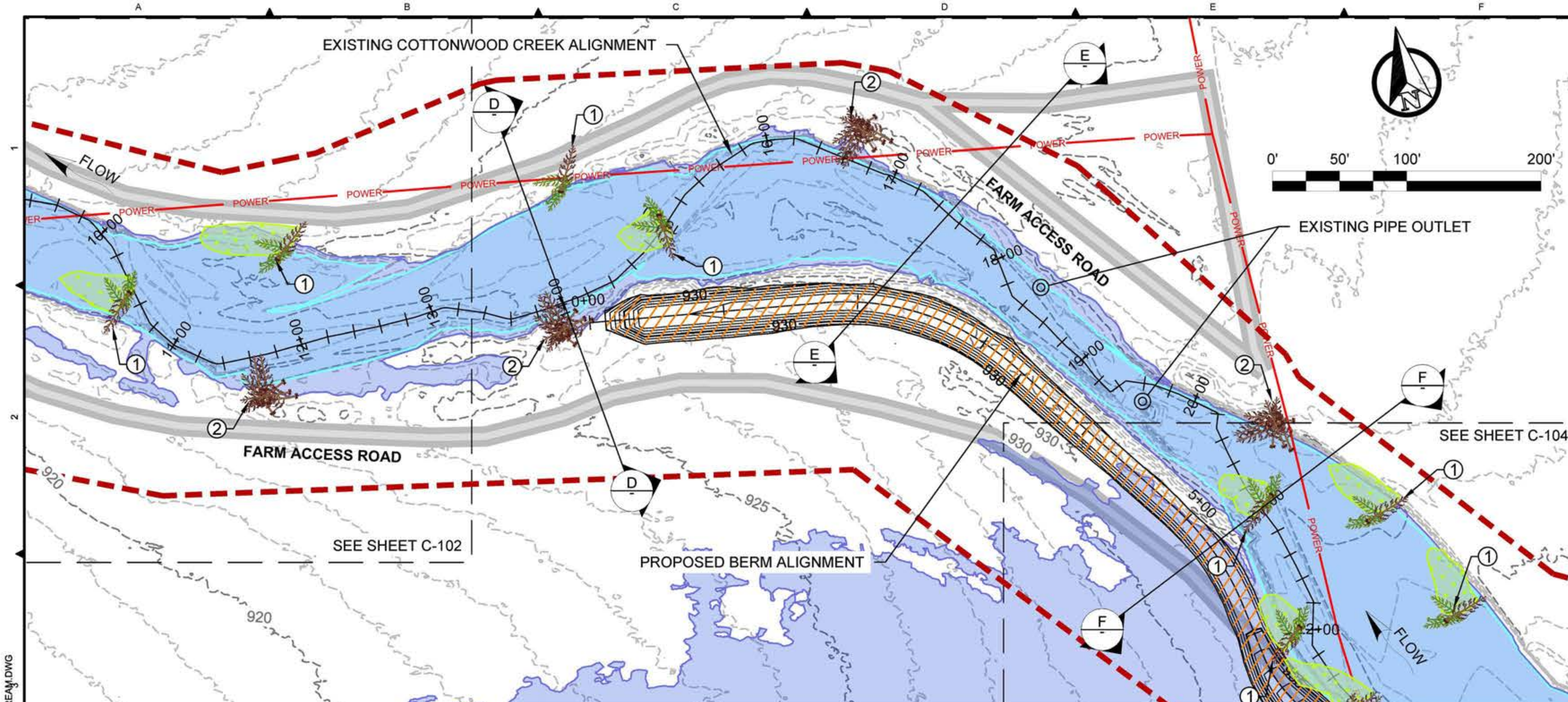
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

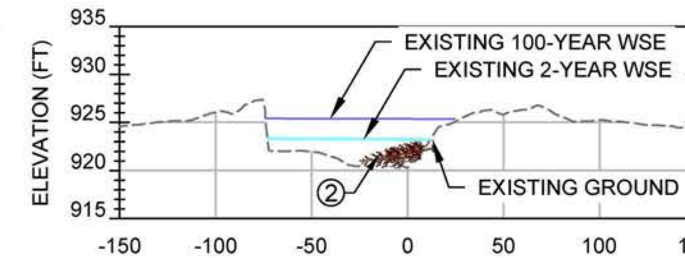
COTTONWOOD CREEK
PALS DESIGN

PROPOSED CONDITIONS
DOWNSTREAM PLAN, PROFILE, AND SECTIONS

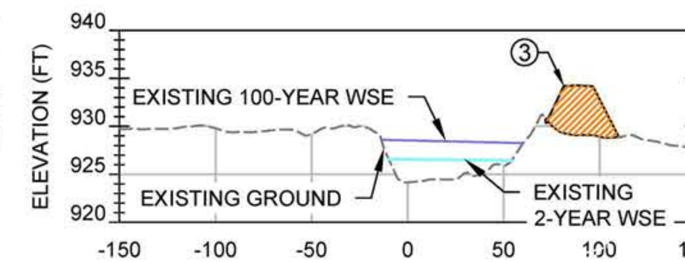
DWG. NO.: C-102
CREATED: 11/30/2022
SHEET: 9 of 20

K:\CAD\PROJECTS\194-1359-002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\04_PROPOSED CONDITIONS DOWNSTREAM.DWG
November 30, 2022 5:21 PM
PLOT DETAILS: ANDREWS, JEREMY

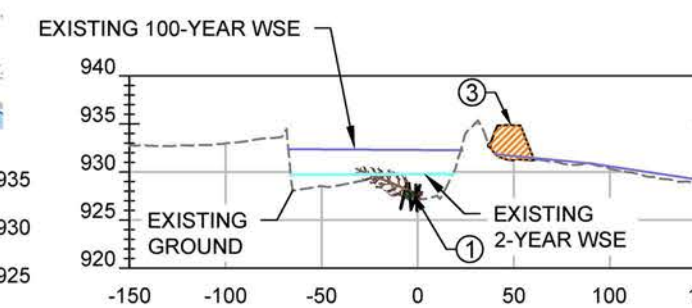




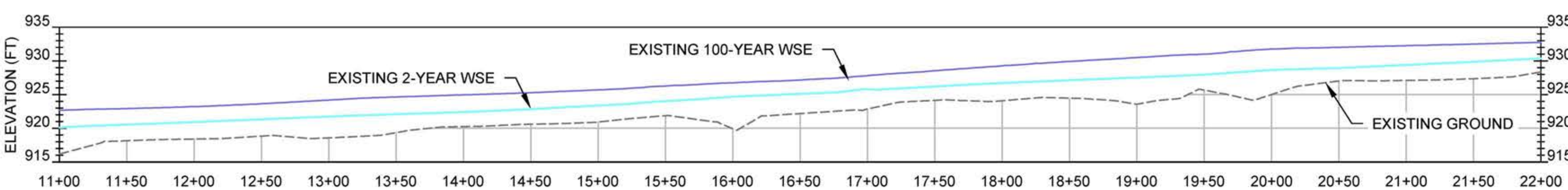
D PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



E PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



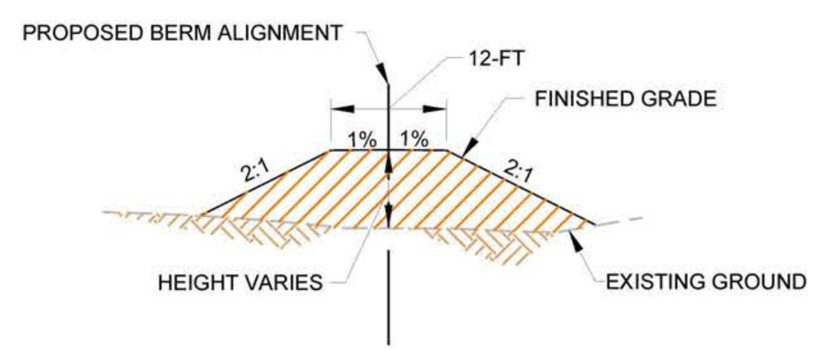
F PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



COTTONWOOD CREEK ALIGNMENT PROFILE STA 11+00 TO STA 22+00 (FT)
(SCALE 1" = 100', 1H:5V)

NOTES:

1. PROPOSED BANK ATTACHED PALS HABITAT FEATURE. SEE SHEET C-109 FOR DETAILS.
2. PROPOSED BANK HABITAT STRUCTURE. SEE SHEET C-110 FOR DETAILS.
3. PROPOSED BERM. SEE DETAIL THIS SHEET FOR TYPICAL CROSS SECTION DETAIL.



PROPOSED BERM TYPICAL CROSS SECTION
(NTS)

LEGEND:

- 1' EXISTING CONTOUR
- 5' EXISTING CONTOUR
- EXISTING ALIGNMENT
- EXISTING POWERLINE
- EXISTING ROAD
- EXISTING 100 YEAR WSE
- EXISTING 2-YEAR WSE
- PROJECT BOUNDARY
- 1' PROPOSED CONTOUR
- 5' PROPOSED CONTOUR
- PROPOSED RIPARIAN PLANTING
- PROPOSED BERM
- SHEET BOUNDARY
- PROPOSED HABITAT FEATURE

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PLAN SHEET SIZE ANSI B (11" X 17")

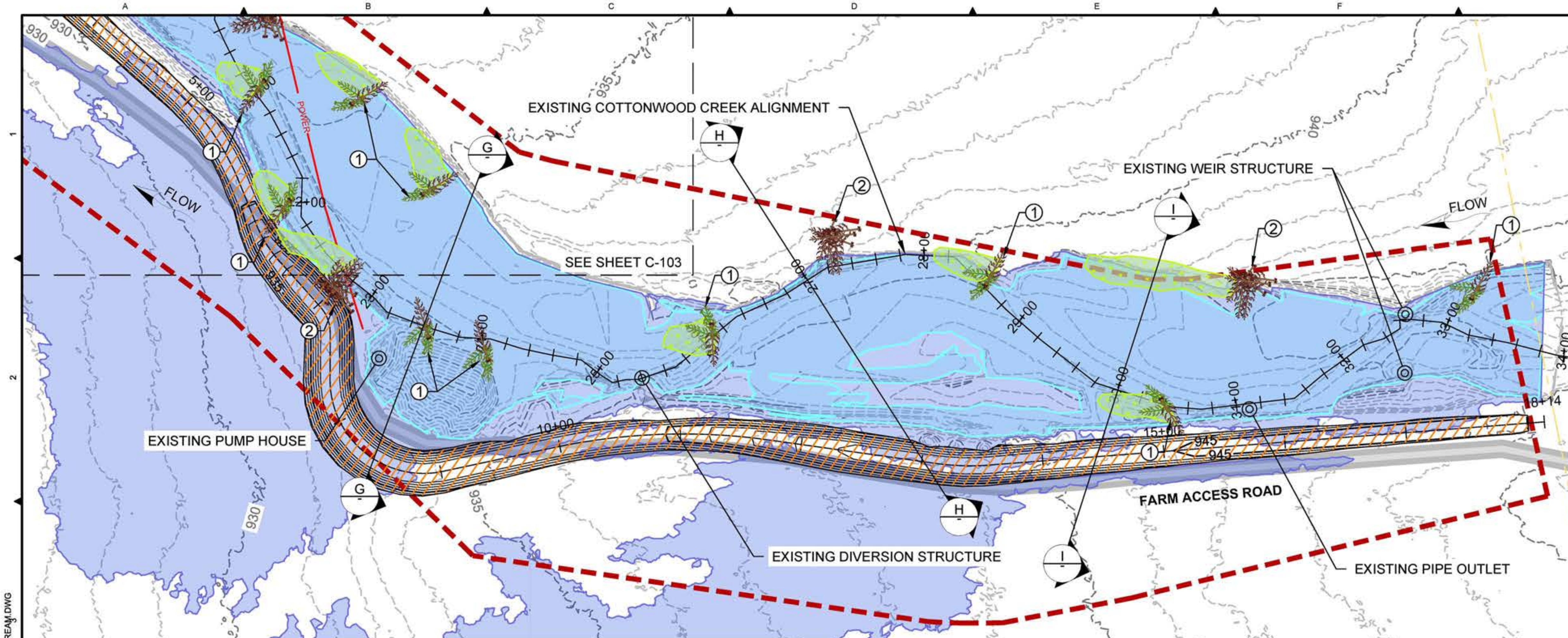
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK PALS DESIGN

PROPOSED CONDITIONS
DOWNSTREAM PLAN, PROFILE, AND SECTIONS

DWG. NO.: C-103
CREATED: 11/30/2022
SHEET: 10 of 20

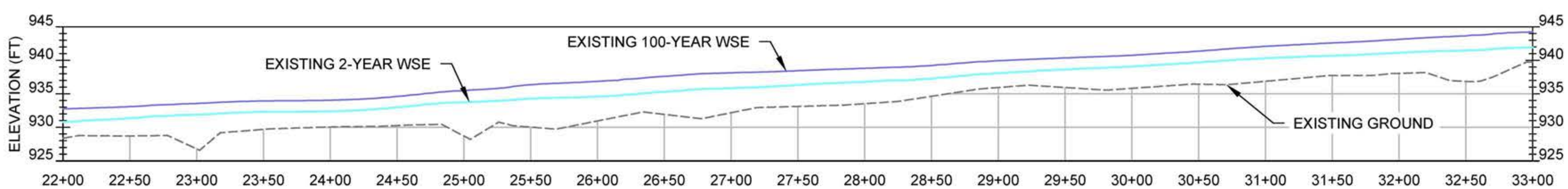
K:\CAD\PROJECTS\194-1359-002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\04_PROPOSED CONDITIONS DOWNSTREAM.DWG
PLOT DETAILS: ANDREWS, JEREMY November 30, 2022 5:23 PM



0' 50' 100' 200'

LEGEND:

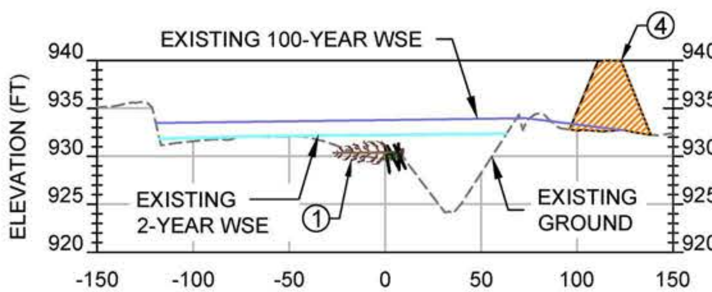
- 1' EXISTING CONTOUR
- 5' EXISTING CONTOUR
- EXISTING ALIGNMENT
- EXISTING POWERLINE
- EXISTING ROAD
- EXISTING 100 YEAR WSE
- EXISTING 2-YEAR WSE
- PROJECT BOUNDARY
- 1' PROPOSED CONTOUR
- 5' PROPOSED CONTOUR
- PROPOSED RIPARIAN PLANTING
- PROPOSED BERM
- SHEET BOUNDARY
- PROPOSED HABITAT FEATURE



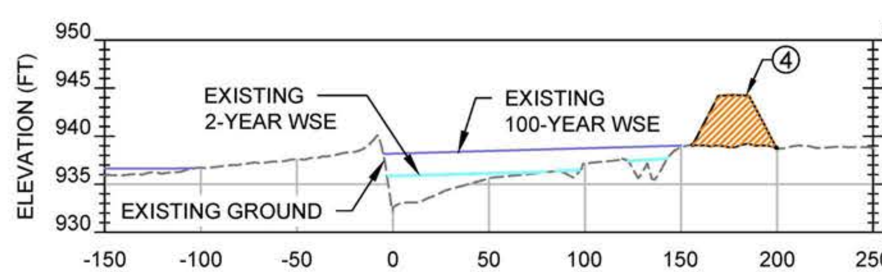
COTTONWOOD CREEK ALIGNMENT PROFILE STA 22+00 TO STA 33+58 (FT)
(SCALE 1" = 100', 1H:5V)

NOTES:

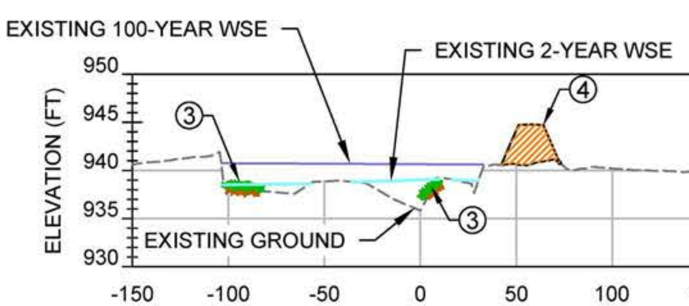
1. PROPOSED BANK ATTACHED PALS HABITAT FEATURE. SEE SHEET C-109 FOR DETAILS.
2. PROPOSED BANK HABITAT STRUCTURE. SEE SHEET C-110 FOR DETAILS.
3. PROPOSED RIPARIAN PLANTING. SEE SHEET L-101 FOR DETAILS.
4. PROPOSED BERM. SEE SHEET C-103 FOR TYPICAL CROSS SECTION DETAIL.



G PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



H PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



I PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V

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PLAN SHEET SIZE ANSI B (11" X 17")

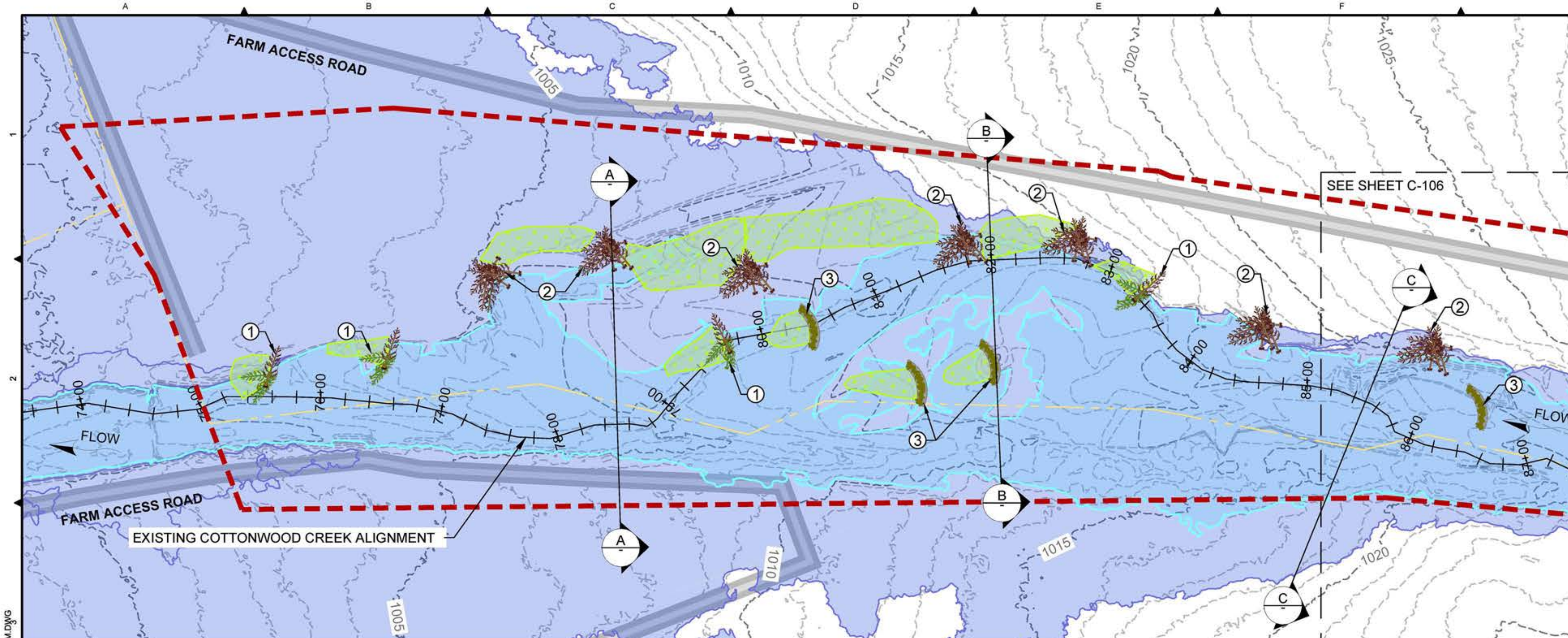
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK
PALS DESIGN

PROPOSED CONDITIONS
DOWNSTREAM PLAN, PROFILE, AND SECTIONS

DWG. NO.: C-104
CREATED: 11/30/2022
SHEET: 11 of 20

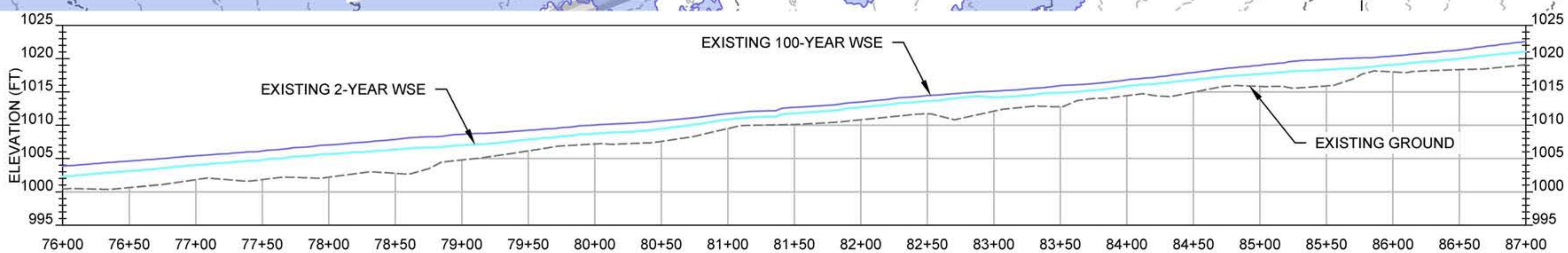
K:\CAD\PROJECTS\194-1359-002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\04_PROPOSED CONDITIONS DOWNSTREAM.DWG
PLOT DETAILS: ANDREWS, JEREMY November 30, 2022 5:29 PM



0' 50' 100' 200'

LEGEND:

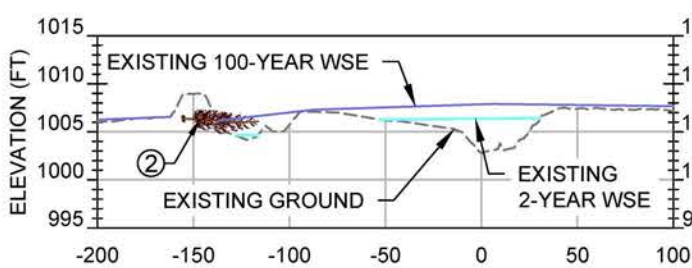
- 1' EXISTING CONTOUR
- 5' EXISTING CONTOUR
- EXISTING ALIGNMENT
- EXISTING ROAD
- PROPERTY BOUNDARY
- EXISTING 100 YEAR WSE
- EXISTING 2-YEAR WSE
- PROJECT BOUNDARY
- PROPOSED RIPARIAN PLANTING
- SHEET BOUNDARY
- PROPOSED HABITAT FEATURE



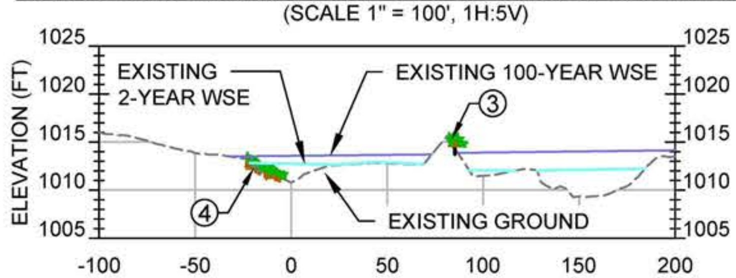
COTTONWOOD CREEK ALIGNMENT PROFILE STA 76+00 TO STA 87+00 (FT)
(SCALE 1" = 100', 1H:5V)

NOTES:

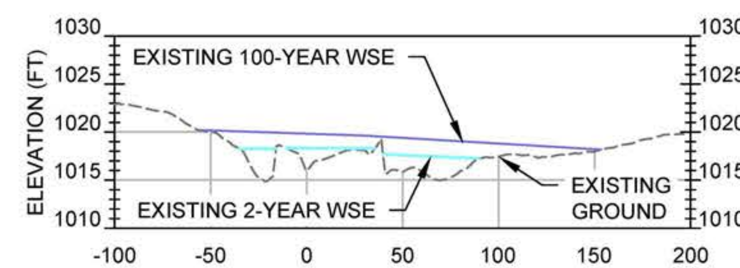
1. PROPOSED BANK ATTACHED PALS HABITAT FEATURE. SEE SHEET C-109 FOR DETAILS.
2. PROPOSED BANK HABITAT STRUCTURE. SEE SHEET C-110 FOR DETAILS.
3. PROPOSED CENTERLINE BDA HABITAT FEATURE. SEE SHEET C-111 FOR FOR DETAILS.
4. PROPOSED RIPARIAN PLANTING. SEE SHEET L-101 FOR DETAILS.



A PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



B PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



C PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V

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PLAN SHEET SIZE ANSI B (11" X 17")

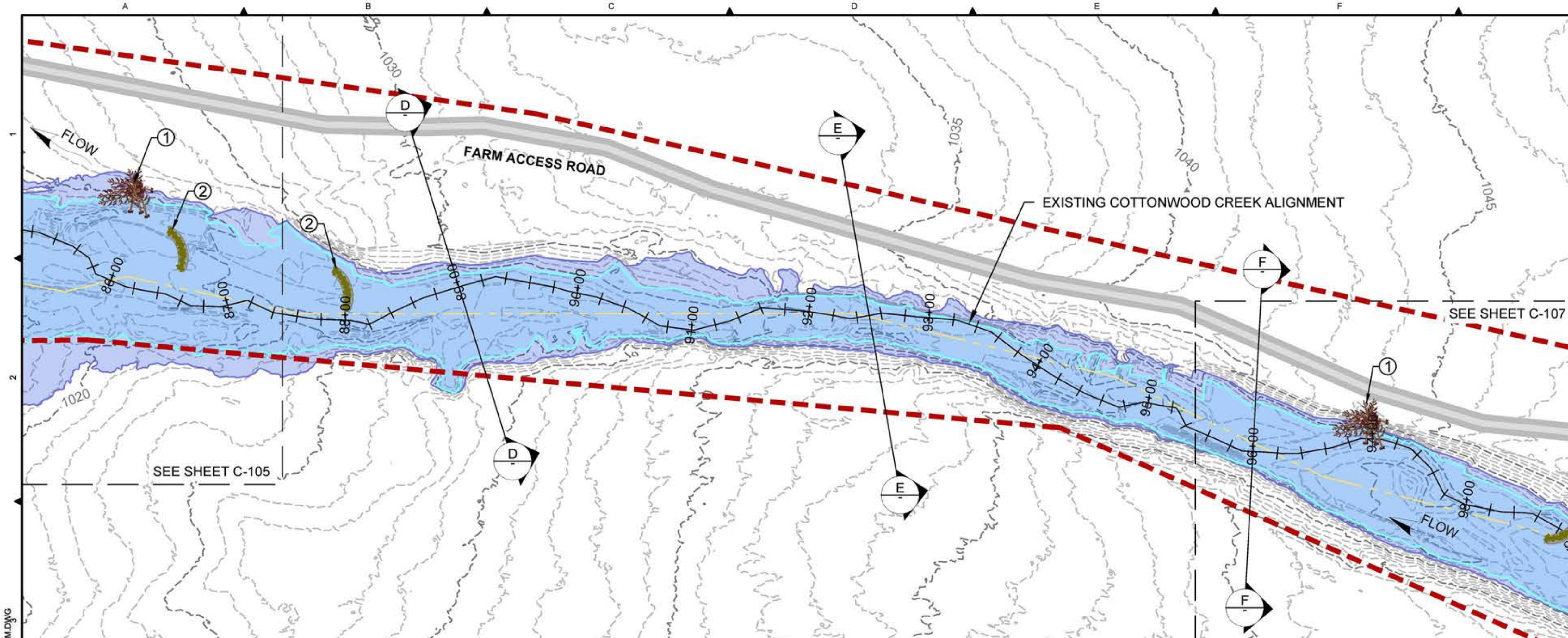
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

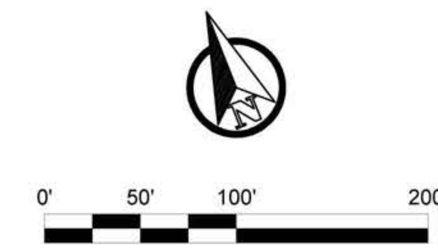
COTTONWOOD CREEK PALS DESIGN

PROPOSED CONDITIONS
UPSTREAM PLAN, PROFILE, AND SECTIONS

DWG. NO.: C-105
CREATED: 11/30/2022
SHEET: 12 of 20

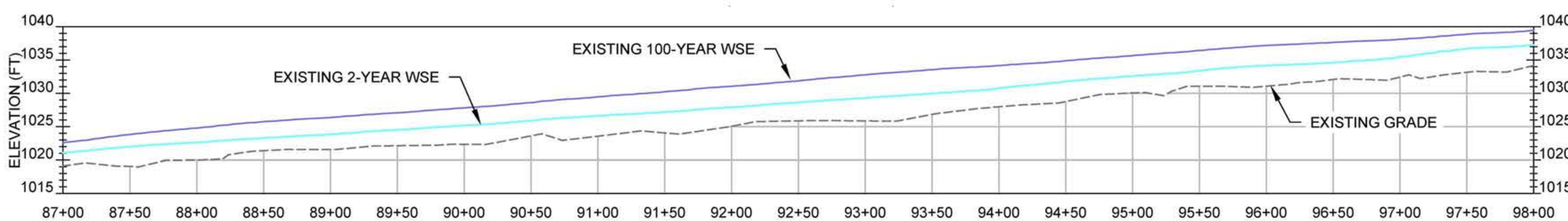
D:\Z\PROJECTS\194-1359-0002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\05.0_PROPOSED CONDITIONS UPSTREAM.DWG
PLOT DETAILS: HARVEY, SPENCER November 30, 2022 5:21 PM





LEGEND:

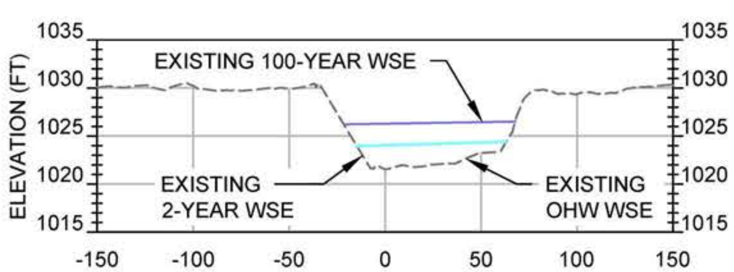
- 1' EXISTING CONTOUR
- 5' EXISTING CONTOUR
- EXISTING ALIGNMENT
- EXISTING ROAD
- PROPERTY BOUNDARY
- EXISTING 100-YEAR WSE
- EXISTING 2-YEAR WSE
- PROJECT BOUNDARY
- PROPOSED RIPARIAN PLANTING
- SHEET BOUNDARY



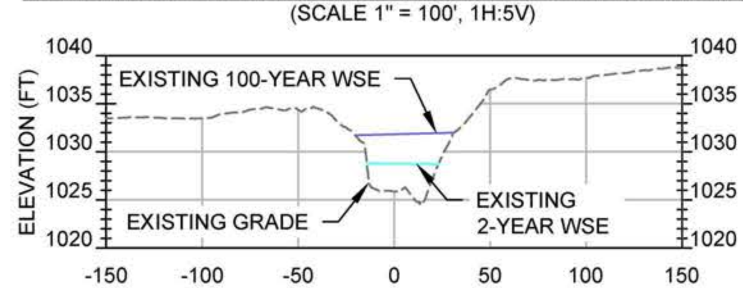
COTTONWOOD CREEK ALIGNMENT PROFILE STA 87+00 TO STA 98+00 (FT)
(SCALE 1" = 100', 1H:5V)

NOTES:

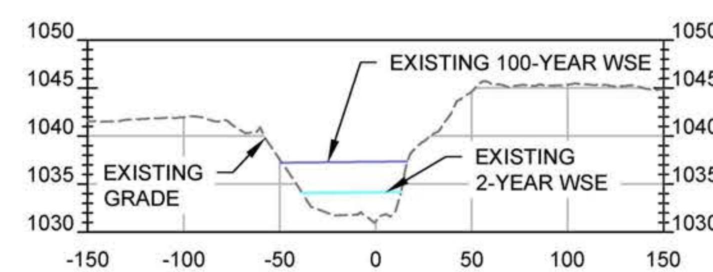
1. PROPOSED BANK HABITAT STRUCTURE. SEE SHEET C-110 FOR DETAILS.
2. PROPOSED CENTERLINE BDA HABITAT FEATURE. SEE SHEET C-111 FOR FOR DETAILS.
3. PROPOSED RIPARIAN PLANTING. SEE SHEET L-101 FOR DETAILS.



D / - PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



E / - PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



F / - PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V

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WALLA WALLA COUNTY CONSERVATION DISTRICT
ESTABLISHED 1941

NOT FOR CONSTRUCTION

PLAN SHEET SIZE ANSI B (11" X 17")

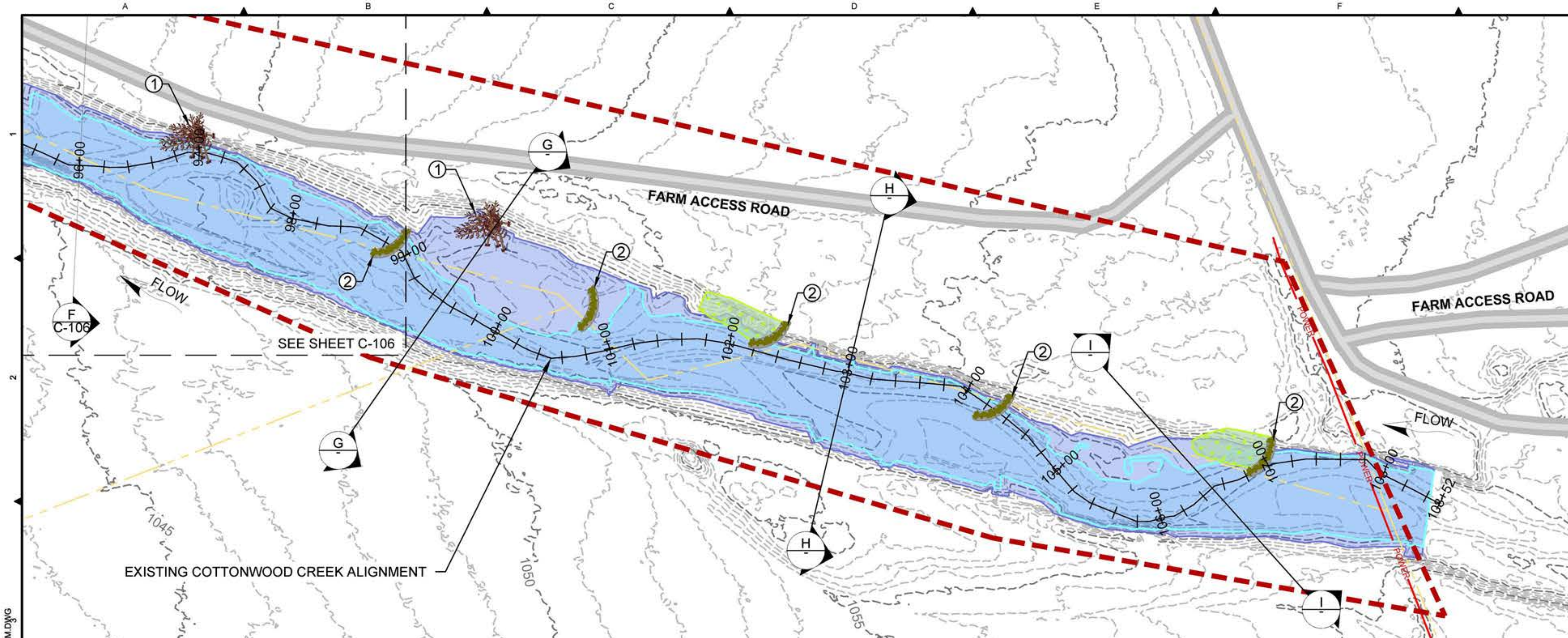
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK
PALS DESIGN

PROPOSED CONDITIONS
UPSTREAM PLAN, PROFILE, AND SECTIONS

DWG. NO.: C-106
CREATED: 11/30/2022
SHEET: 13 of 20

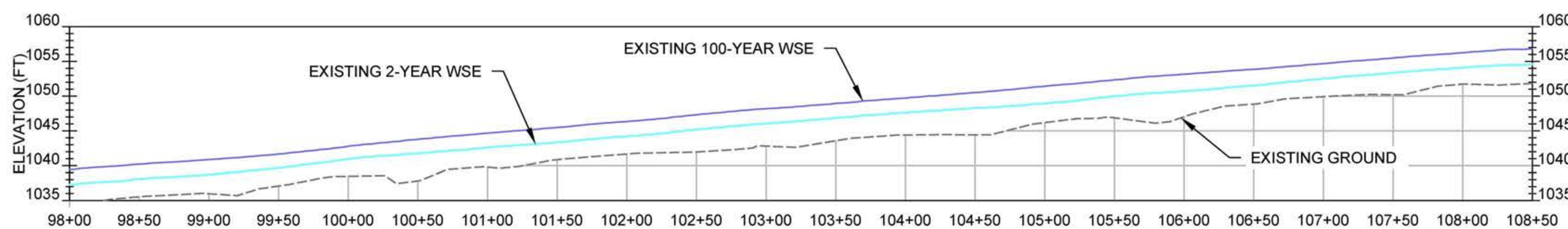
D:\Z\PROJECTS\194-1359-0002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\05.0_PROPOSED CONDITIONS UPSTREAM.DWG
PLOT DETAILS: HARVEY, SPENCER November 30, 2022 5:29 PM



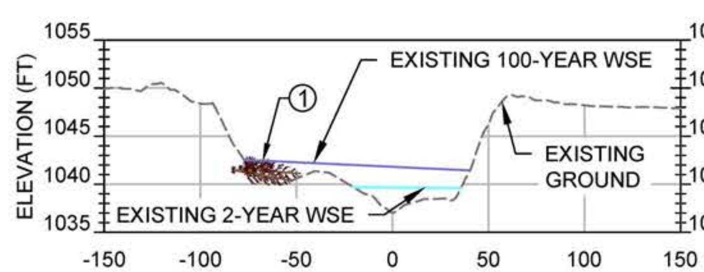
0' 50' 100' 200'

LEGEND:

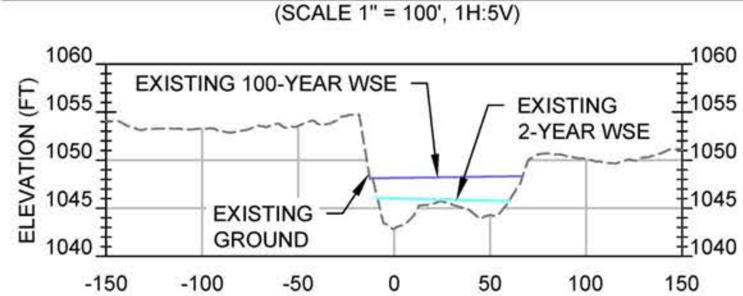
- 1' EXISTING CONTOUR
- 5' EXISTING CONTOUR
- EXISTING ALIGNMENT
- EXISTING POWERLINE
- EXISTING ROAD
- PROPERTY BOUNDARY
- EXISTING 100 YEAR WSE
- EXISTING 2-YEAR WSE
- PROJECT BOUNDARY
- PROPOSED RIPARIAN PLANTING
- SHEET BOUNDARY
- PROPOSED HABITAT FEATURE



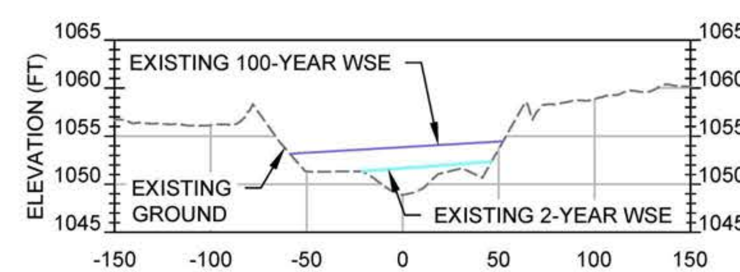
COTTONWOOD CREEK ALIGNMENT PROFILE STA 98+00 TO STA 108+50 (FT)
(SCALE 1" = 100', 1H:5V)



G
-
PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



H
-
PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V



I
-
PROPOSED CHANNEL SECTION VIEW
SCALE 1" = 100', 1H:5V

NOTES:

1. PROPOSED BANK HABITAT STRUCTURE. SEE SHEET C-110 FOR DETAILS.
2. PROPOSED CENTERLINE BDA HABITAT FEATURE. SEE SHEET C-111 FOR FOR DETAILS.
3. PROPOSED RIPARIAN PLANTING. SEE SHEET L-101 FOR DETAILS.

D:\Z\PROJECTS\194-1359-0002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\05.0_PROPOSED CONDITIONS UPSTREAM.DWG
PLOT DETAILS: HARVEY, SPENCER November 30, 2022 5:34 PM

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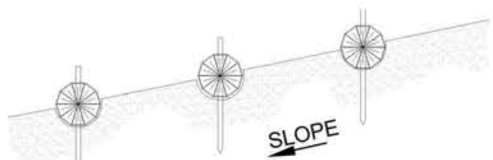
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

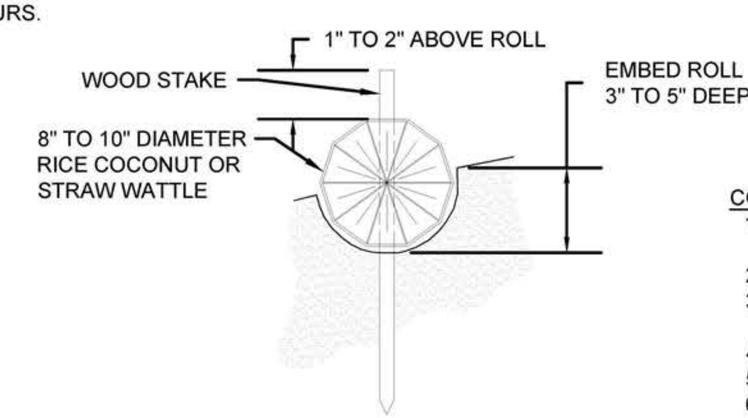
COTTONWOOD CREEK
PALS DESIGN

PROPOSED CONDITIONS
UPSTREAM PLAN, PROFILE, AND SECTIONS

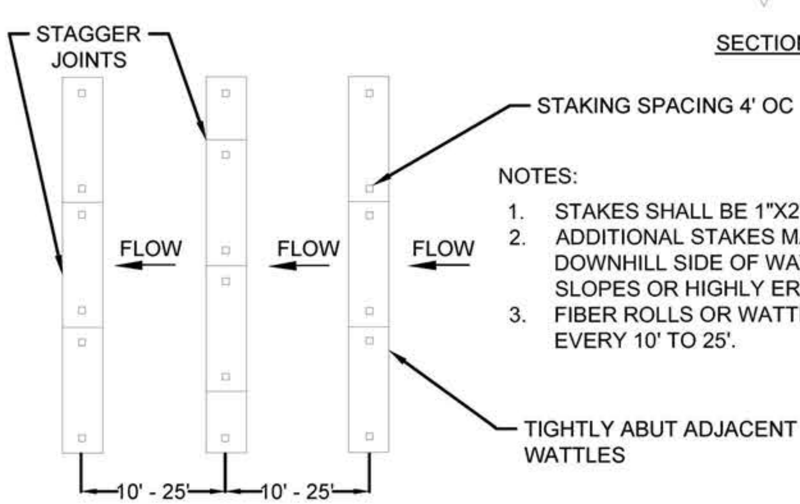
DWG. NO.: C-107
CREATED: 11/30/2022
SHEET: 14 of 20



PROFILE



SECTION

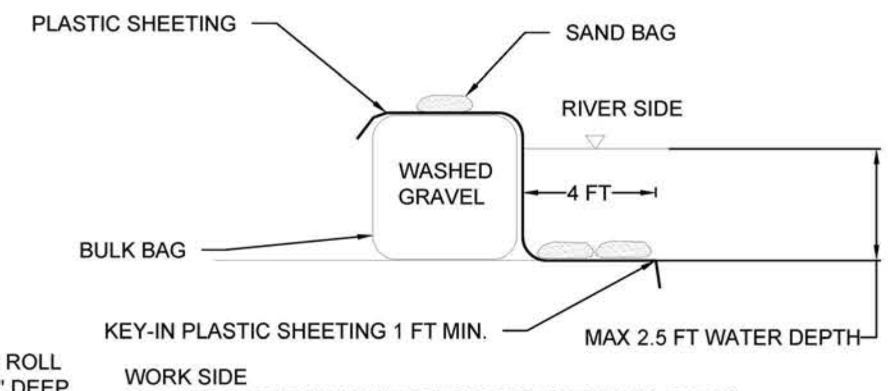


PLAN VIEW

NOTES:

1. STAKES SHALL BE 1"X2" WOODEN STAKES.
2. ADDITIONAL STAKES MAY BE INSTALLED ON DOWNHILL SIDE OF WATTLES, ON STEEP SLOPES OR HIGHLY EROSIVE SOILS
3. FIBER ROLLS OR WATTLES TO BE INSTALLED EVERY 10' TO 25'.

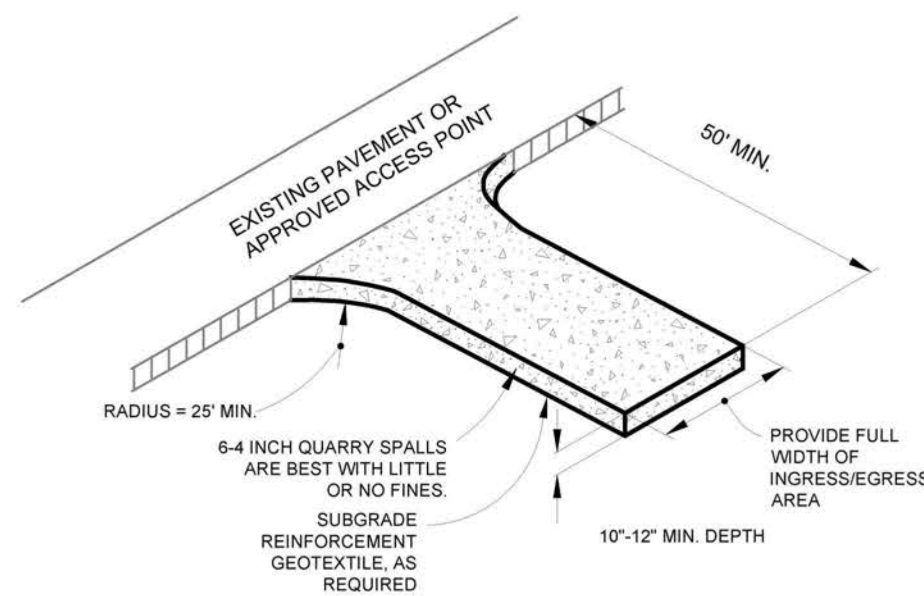
FIBER ROLLS/WATTLES - TYPICAL DETAIL
NTS



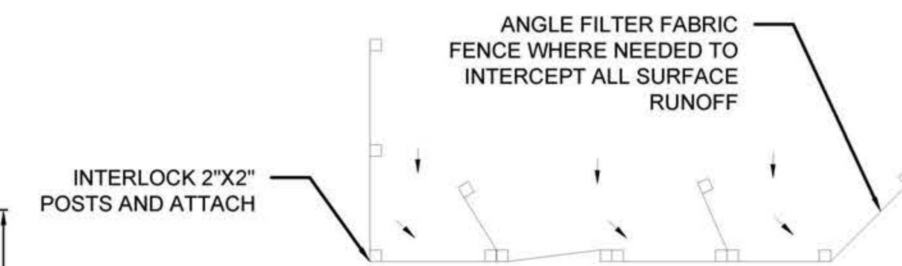
TEMPORARY COFFERDAM SECTION TYPICAL DETAIL
NTS

COFFERDAM NOTES:

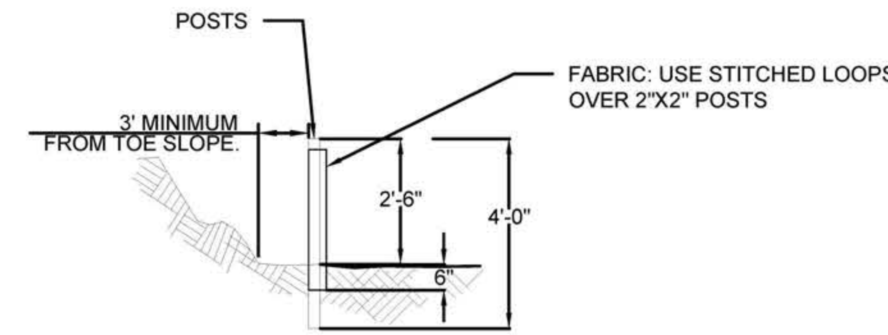
1. ALL WORK IN CHANNEL SHALL ONLY OCCUR IN THE ALLOWABLE IN-WATER WORK WINDOW.
2. IN-WATER WORK AREAS SHALL BE ISOLATED BY COFFERDAMS.
3. ISOLATED AREAS REQUIRE FISH SALVAGE ACTIVITIES PRIOR TO THE INITIATION OF CONSTRUCTION.
4. FISH SALVAGE TO BE PERFORMED BY QUALIFIED FISH BIOLOGIST.
5. FILL BULK BAG WITH WASHED GRAVEL.
6. SAND BAGS, ECO-BLOCKS, OR SIMILAR MAY BE SUBSTITUTED FOR WASHED GRAVEL BULK BAGS.



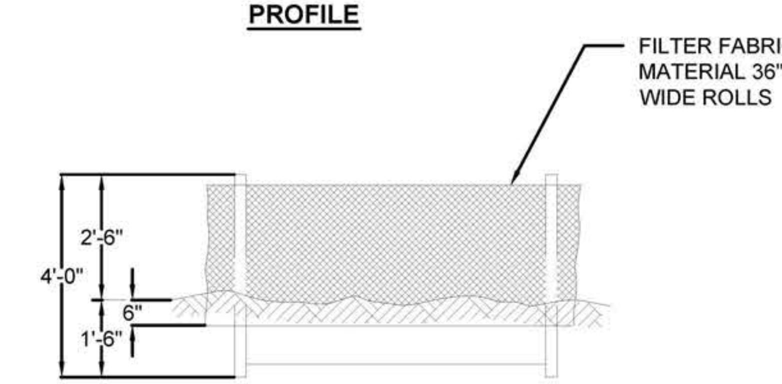
VEHICLE ENTRANCE - TYPICAL DETAIL
NTS



PLAN VIEW



PROFILE



SECTION VIEW

TEMPORARY SILT FENCE TYPICAL DETAIL
NTS

SEDIMENT FENCE NOTES:

1. SEDIMENT FENCE SHALL BE INSTALLED ON A LINE OF EQUAL ELEVATION.
2. BOTTOM EDGE OF SEDIMENT FENCE SHALL BE BURIED MIN 6".
3. POSTS MAY BE 2"X2" FIR, PINE OR STEEL.
4. POSTS TO BE INSTALLED ON UPHILL SIDE OF SLOPE.
5. COMPACT BOTH SIDES OF FILTER FABRIC TRENCH.
6. SEDIMENT SHALL BE REMOVED WHEN ACCUMULATION REACHES 1/3 OF THE MEASURE HEIGHT. SEDIMENT SHALL BE DISPOSED OF TO AN AREA THAT CAN BE PERMANENTLY STABILIZED.

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PLAN SHEET SIZE ANSI B (11" X 17")

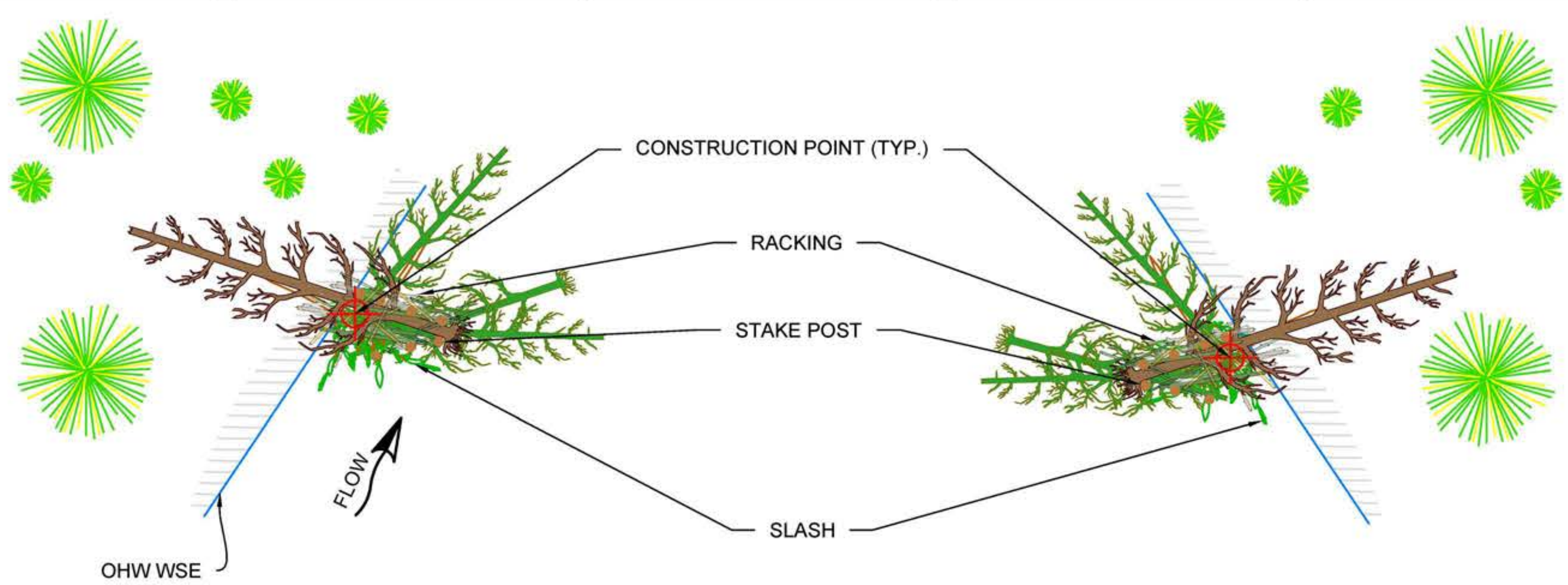
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK PALS DESIGN

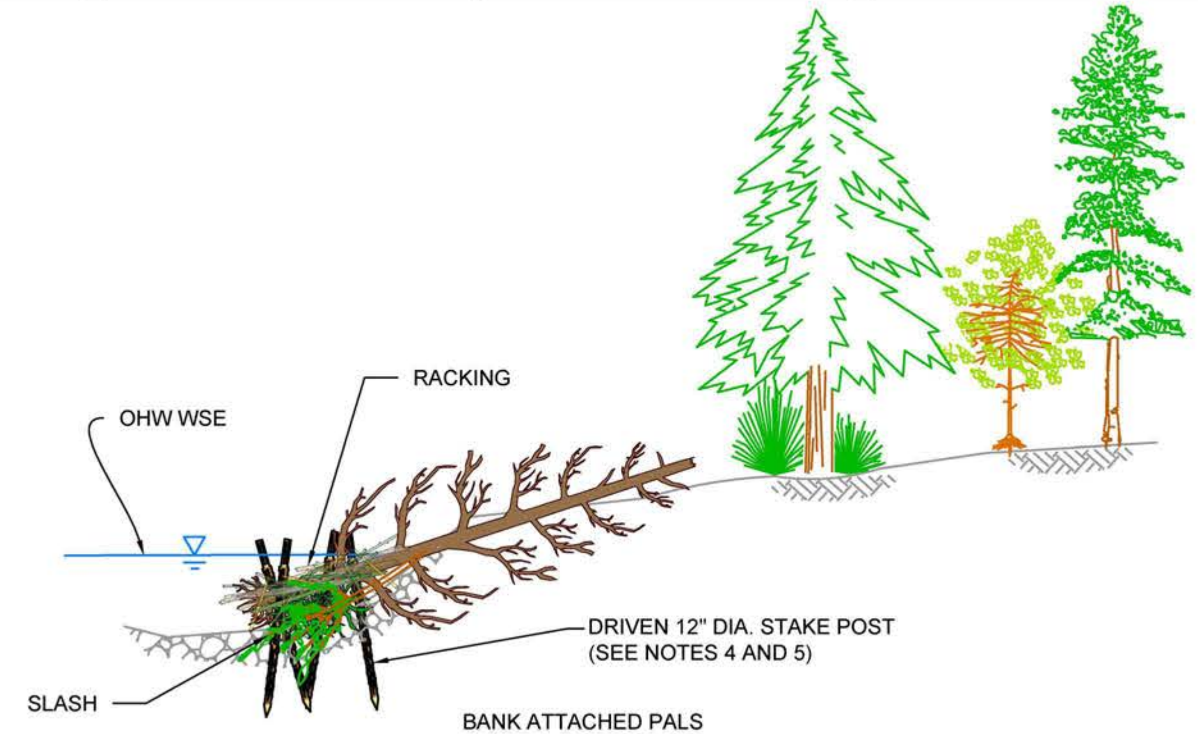
DETAILS
TESC

DWG. NO.: C-108
CREATED: 11/30/2022
SHEET: 15 of 20

D:\Z\PROJECTS\194-1359-0002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\06_DETAILS TESC.DWG
PLOT DETAILS: HARVEY, SPENCER November 30, 2022 4:53 PM



BANK ATTACHED PALS
TYPICAL PLAN LAYOUTS (NTS)



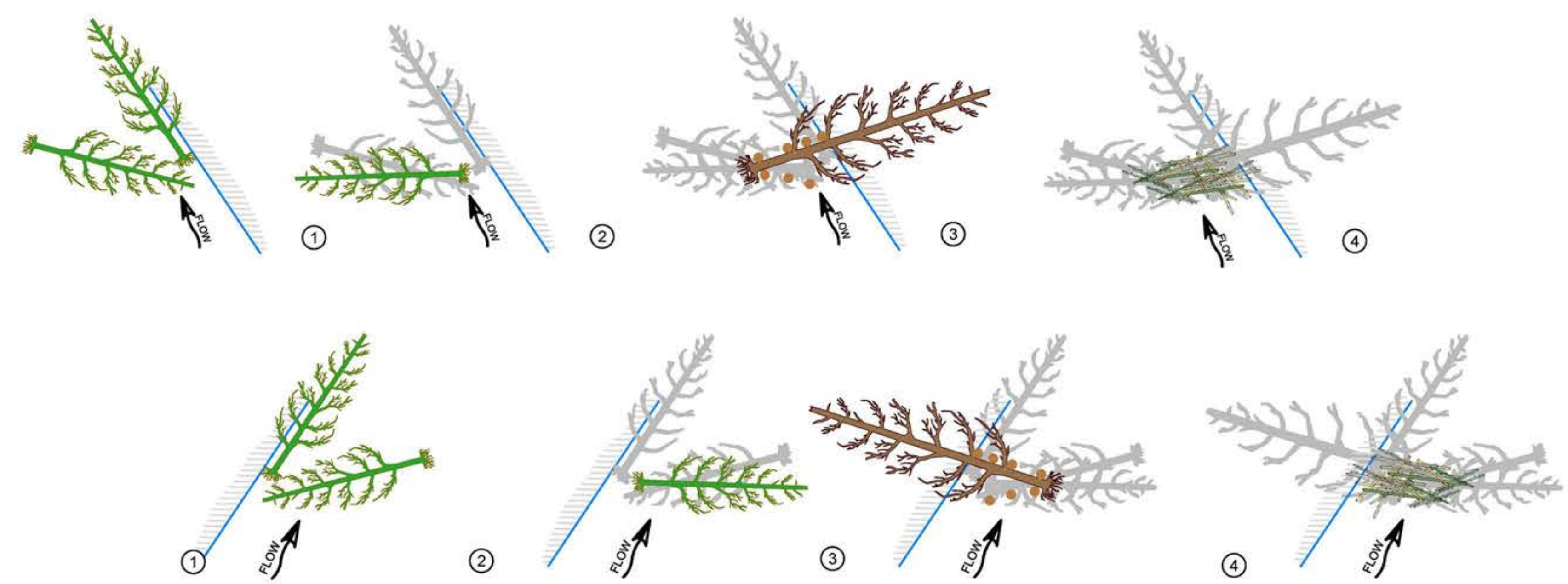
BANK ATTACHED PALS
TYPICAL SECTION (NTS)

BANK ATTACHED PALS NOTES:

1. OHW WSE LOCATION WITH RESPECT TO STRUCTURE LOCATION IS A TYPICAL REPRESENTATION AND MAY VARY AT EACH STRUCTURE LOCATION. FINAL CONFIGURATION OF STRUCTURE SHALL BE AS DIRECTED IN FIELD.
2. PLACE SLASH MATERIAL PERPENDICULAR TO CHANNEL THEN PLACE TREES PER LOG PLACEMENT SEQUENCING.
3. ADD RACKING MATERIAL TO HELP STABILIZE KEY MEMBERS AND FILL VOIDS. RACKING MATERIAL MAY CONSIST OF TOPS AND LIMBS OF WHOLE TREES.
4. STAKE POSTS SHALL BE INSTALLED WITH HAND-HELD PNEUMATIC POUNDER OR MECHANICAL POST POUNDER ATTACH TO EXCAVATOR. ALL POUNDERS SHALL HAVE MEANS TO HOLD POST IN PLACE AND MAINTAIN VERTICAL ORIENTATION DURING DRIVING OPERATION.

CONSTRUCTION QUANTITIES:

COMPONENT	DESCRIPTION	QUANTITY
WHOLE TREE	MEDIUM (18" DBH, 35 FT MIN, 4 FT MIN ROOTWAD)	1
WHOLE TREE	SMALL (16" DBH, 25 FT MIN, 3 FT MIN ROOTWAD)	3
RACKING	MISC. (4-10" DBH, 10 FT MIN, 20 FT MAX)	8
POSTS	STAKE (12" Ø, 10 FT MIN)	7
SLASH	MISC. (4" MAX DBH, 8 FT MAX)	5 CY



BANK ATTACHED PALS - LOG PLACEMENT SEQUENCING

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PLAN SHEET SIZE ANSI B (11" X 17")

REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK
PALS DESIGN

HABITAT FEATURES DETAILS
BANK ATTACHED PALS

DWG. NO.: C-109
CREATED: 11/30/2022
SHEET: 16 of 20

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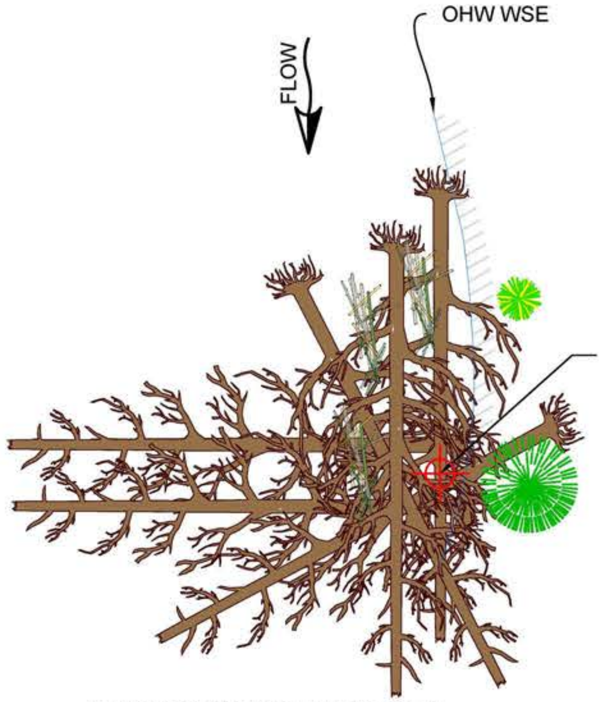
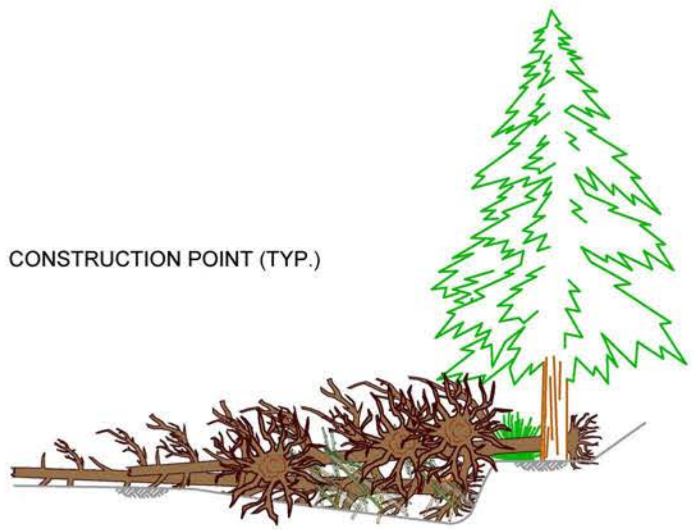
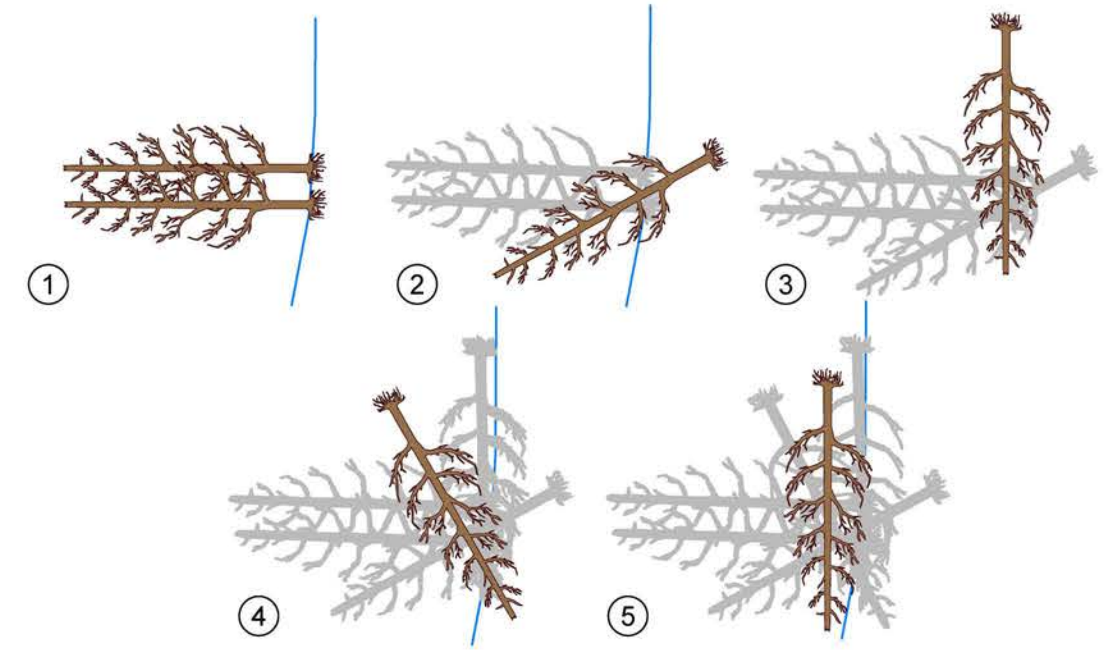
PLOT DETAILS: HARVEY, SPENCER November 30, 2022 4:56 PM



LEFT BANK HABITAT STRUCTURE
TYPICAL PLAN LAYOUT (NTS)



LEFT BANK BANK HABITAT STRUCTURE
TYPICAL SECTION (NTS)



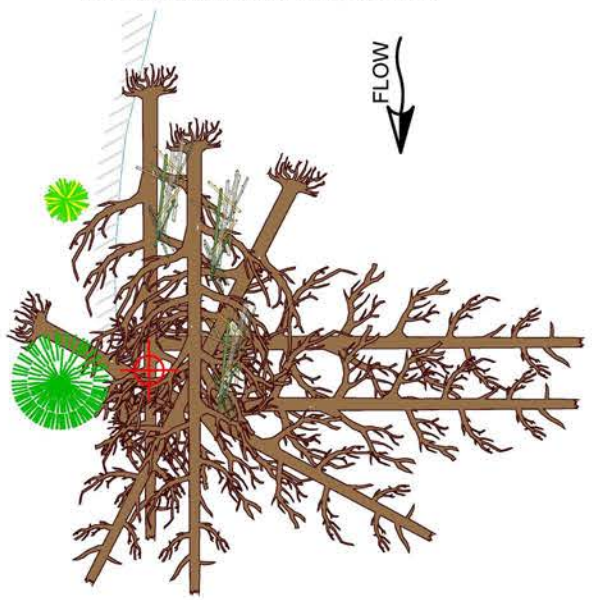
LEFT BANK HABITAT STRUCTURE - LOG PLACEMENT SEQUENCING

BANK HABITAT STRUCTURE NOTES:

1. INSTALL TEMPORARY COFFERDAM TO ISOLATE WORK AREA WHEN NEEDED
2. FISH SALVAGE TO BE SUPERVISED BY QUALIFIED FISH BIOLOGIST.
3. FIRST TWO LOGS PLACED SHALL BE LARGEST OF THREE LOGS USED TO CONSTRUCT STRUCTURES.
4. PLACE ROOTWAD OF LOGS PLACED IN SEQUENCE #1 1 TO 2 FEET FROM BANK FACE.
5. PLACE ROOTWAD OF THIRD LOG ON TOP OF BANK. PLACE UPSTREAM OF ANY EXISTING VEGETATION.
6. PLACE ROOTWAD OF FOURTH LOG IN CHANNEL.
7. PLACE ROOTWAD OF FIFTH LOG ON OPPOSITE EDGE OF WATER.
8. PLACE ROOTWAD OF SIXTH LOG IN CHANNEL.
9. OHW WSE WITH RESPECT TO STRUCTURE ORIENTATION IS A TYPICAL REPRESENTATION AND WILL VARY AT EACH STRUCTURE LOCATION.

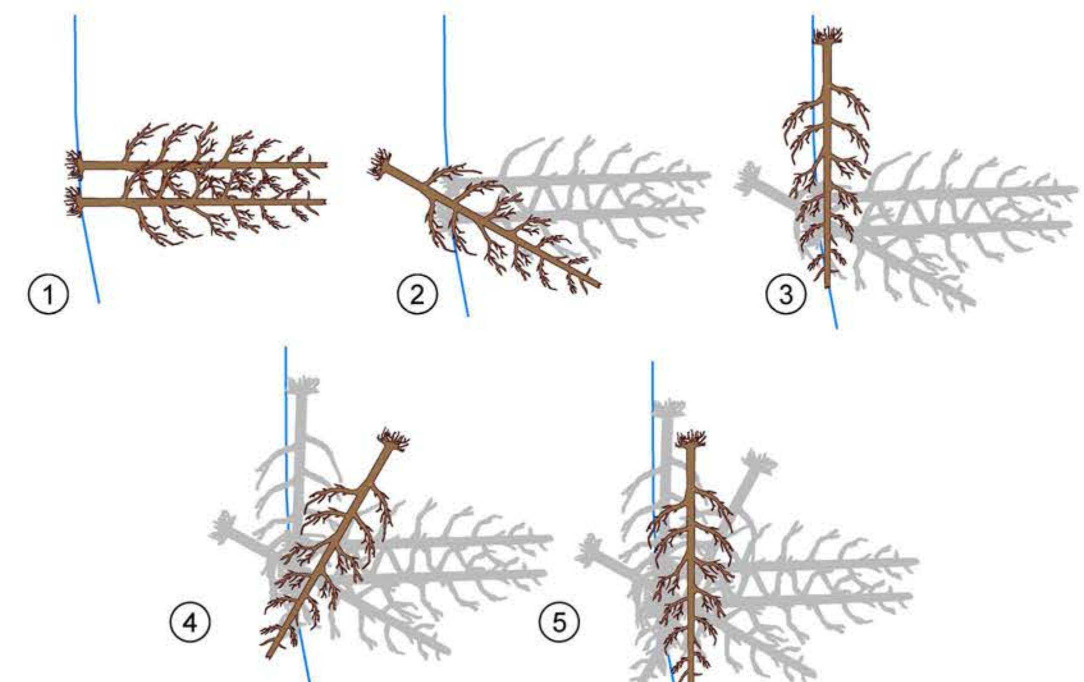
CONSTRUCTION QUANTITIES:

COMPONENT	DESCRIPTION	QUANTITY
WHOLE TREE	MEDIUM (16-18"+ DBH, 35 FT MIN, 3 FT MIN ROOTWAD)	6
RACKING/SLASH	MISC. (4-10" DBH, 10 FT MIN, 20 FT MAX)	15
BALLAST	SPOILS/FLOODPLAIN ALLUVIUM	40 CY



RIGHT BANK HABITAT STRUCTURE
TYPICAL PLAN LAYOUT (NTS)

RIGHT BANK HABITAT STRUCTURE
TYPICAL SECTION (NTS)



RIGHT BANK HABITAT STRUCTURE - LOG PLACEMENT SEQUENCING

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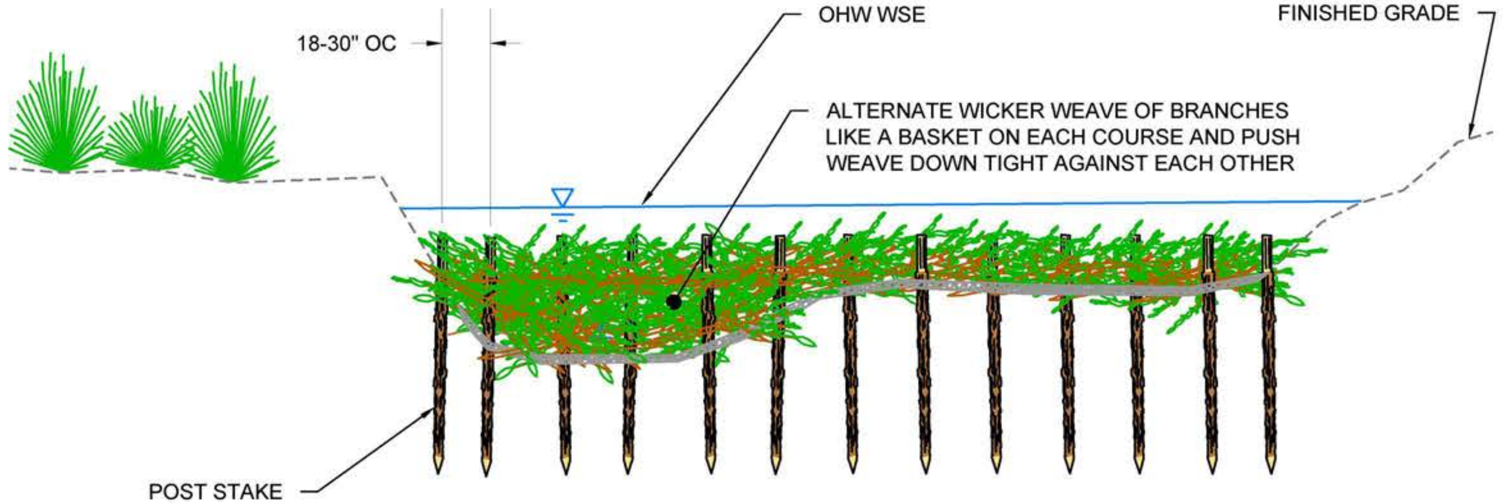
PLAN SHEET SIZE ANSI B (11" X 17")

REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

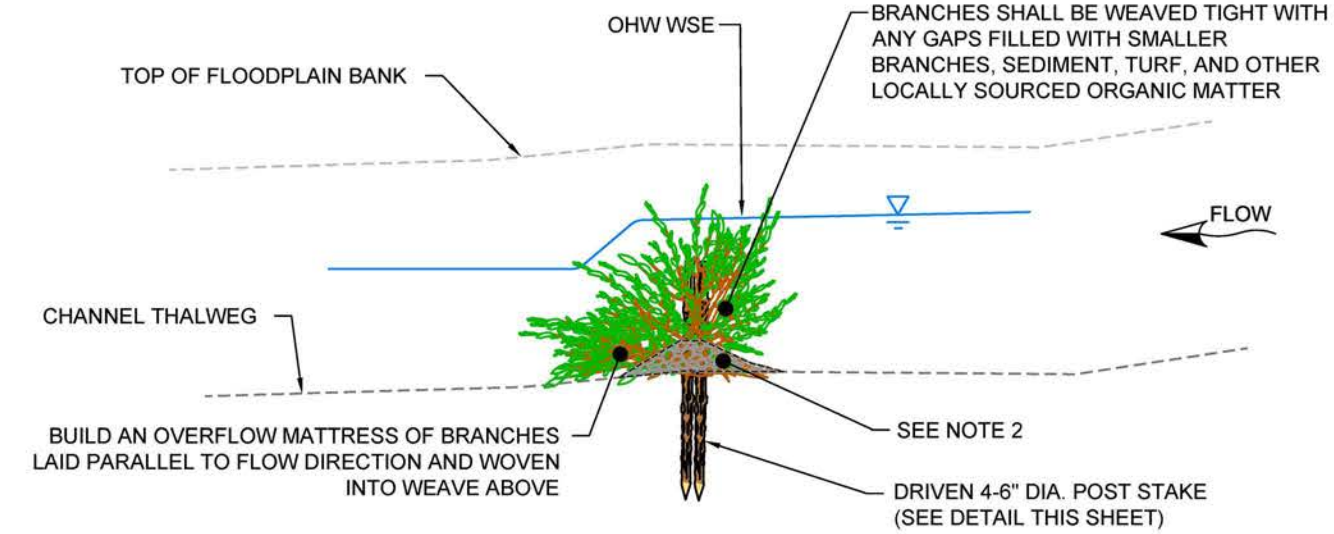
COTTONWOOD CREEK
PALS DESIGN

HABITAT FEATURES DETAILS
BANK HABITAT STRUCTURE

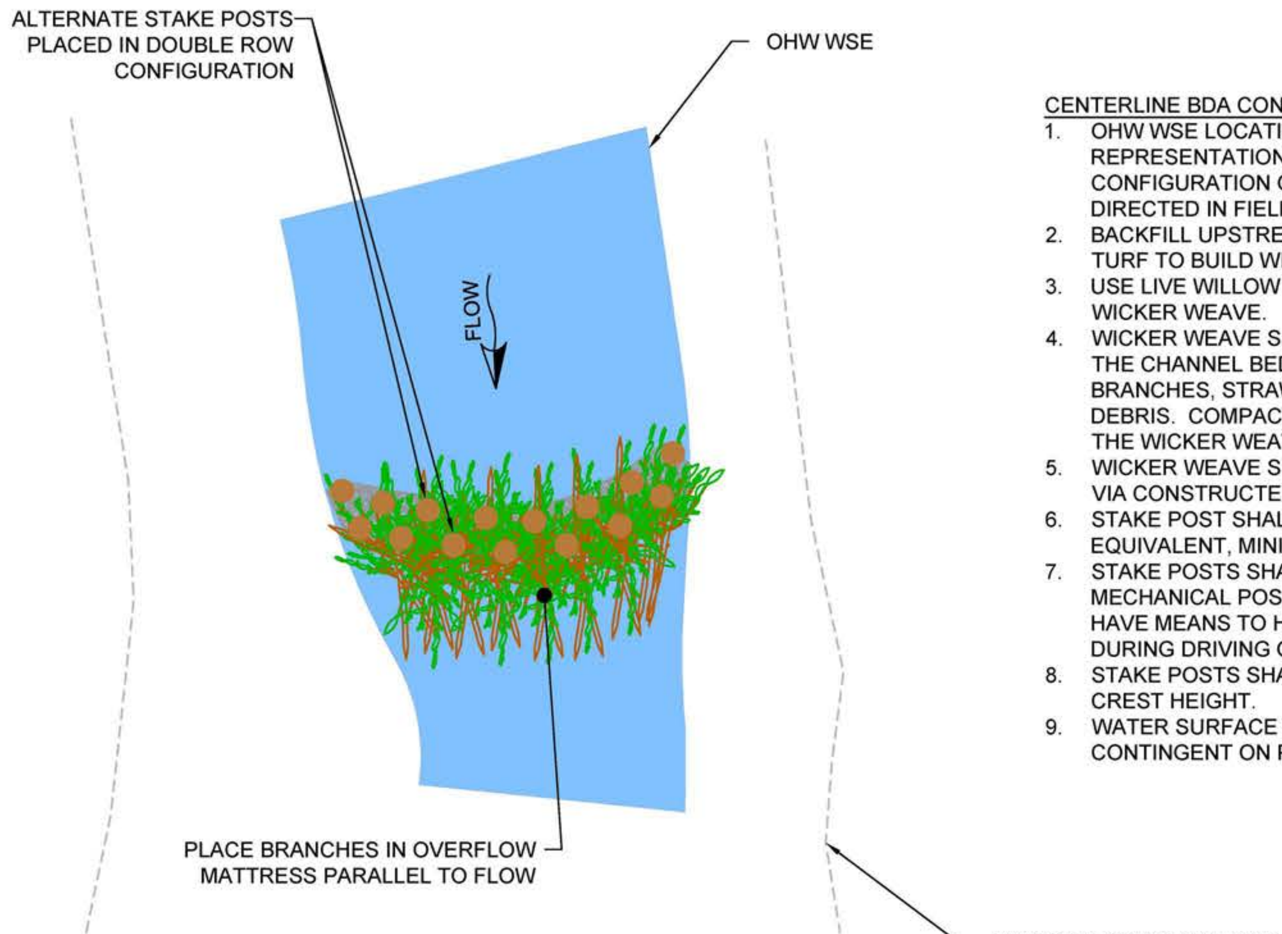
DWG. NO.: C-110
CREATED: 11/30/2022



CENTERLINE BDA
TYPICAL SECTION (NTS)



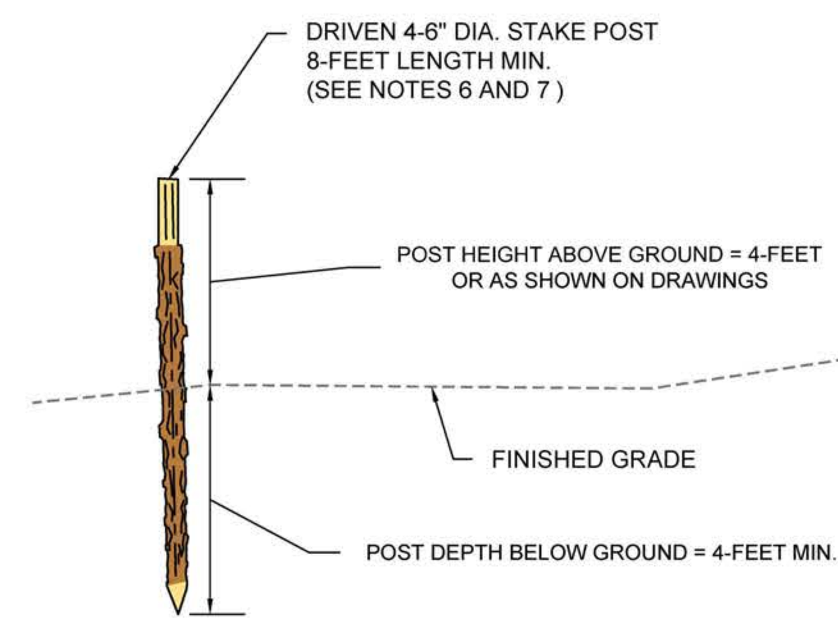
CENTERLINE BDA
TYPICAL PROFILE (NTS)



CENTERLINE BDA
TYPICAL PLAN LAYOUT (NTS)

CENTERLINE BDA CONSTRUCTION NOTES:

1. OHW WSE LOCATION WITH RESPECT TO STRUCTURE LOCATION IS A TYPICAL REPRESENTATION AND MAY VARY AT EACH STRUCTURE LOCATION. FINAL CONFIGURATION OF STRUCTURE AND UNIFORM CREST ELEVATION SHALL BE AS DIRECTED IN FIELD. HEIGHT OF STRUCTURE SHALL BE LESS THAN 5 FEET.
2. BACKFILL UPSTREAM SIDE WITH BED SEDIMENT AND OR LOCALLY SOURCED TURF TO BUILD WIDE BASE AND HELP PREVENT SEAPAGE.
3. USE LIVE WILLOW OR RED OSIER DOGWOOD BRANCH CUTTINGS FOR WOVEN WICKER WEAVE.
4. WICKER WEAVE SHALL COVER THE ENTIRE POST LINE AND BE ANCHORED INTO THE CHANNEL BED AND SIDE BANKS BY LOCALLY SOURCED COMPACTED MIX OF BRANCHES, STRAW, SMALL GRAVEL, SILTY MATERIAL, AND OTHER ORGANIC DEBRIS. COMPACTED MATERIAL MIX SHALL PROVIDE AN ANCHOR AND SEAL FOR THE WICKER WEAVER.
5. WICKER WEAVE SHALL BE POROUS IN THE CENTER BODY AND FISH PASSABLE VIA CONSTRUCTED INTERSTITIAL SPACE.
6. STAKE POST SHALL BE NON-PRESSURE TREATED LODGE POLE PINE OR EQUIVALENT, MINIMUM OF 8-FEET TOTAL LENGTH.
7. STAKE POSTS SHALL BE INSTALLED WITH HAND-HELD PNEUMATIC POUNDER OR MECHANICAL POST POUNDER ATTACH TO EXCAVATOR. ALL POUNDERS SHALL HAVE MEANS TO HOLD POST IN PLACE AND MAINTAIN VERTICAL ORIENTATION DURING DRIVING OPERATION.
8. STAKE POSTS SHALL BE BURIED SO TOPS OF EACH ARE IN LINE WITH UNIFORM CREST HEIGHT.
9. WATER SURFACE CONDITIONS UPSTREAM OF BDA WILL VARY AND IS CONTINGENT ON POROSITY AND QUALITY OF WICKER WEAVE.



TYPICAL POST STAKE DETAIL
NTS

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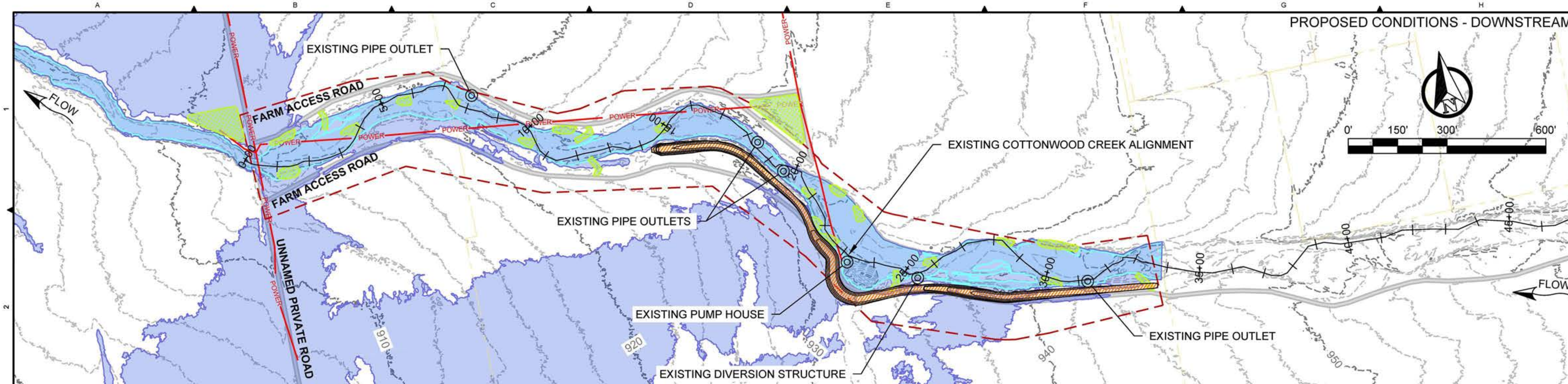
REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK
PALS DESIGN

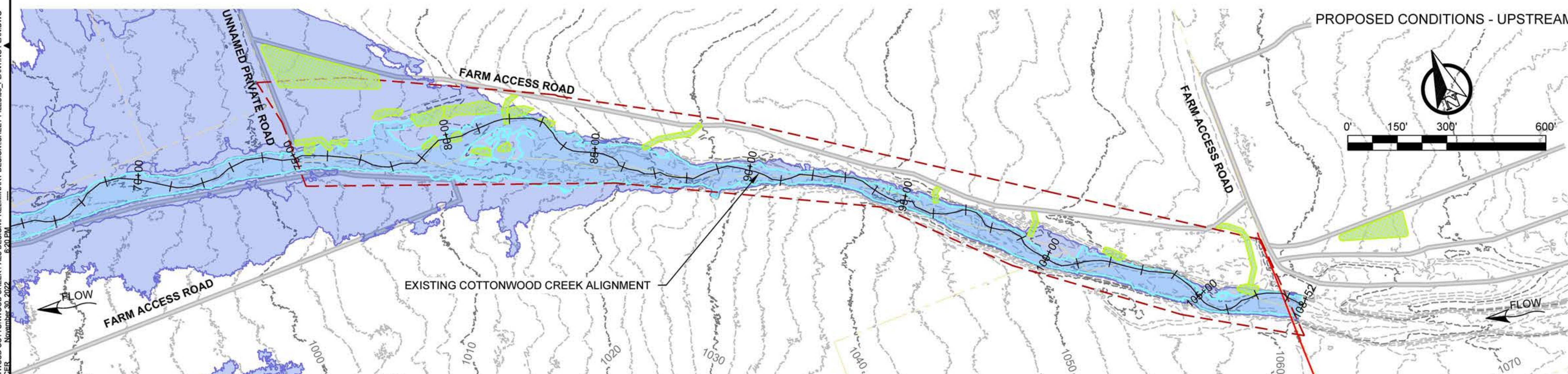
HABITAT FEATURES DETAILS
CENTERLINE BDA

DWG. NO.: C-111
CREATED: 11/30/2022
SHEET: 18 of 20



LEGEND:

2' EXISTING CONTOUR	EXISTING 100-YEAR WSE
10' EXISTING CONTOUR	EXISTING 2-YEAR WSE
EXISTING ALIGNMENT	PROPOSED BERM
EXISTING POWERLINE	PROJECT BOUNDARY
EXISTING ROAD	PROPOSED RIPARIAN PLANTING
PROPERTY BOUNDARY	
2" PROPOSED CONTOUR	
10" PROPOSED CONTOUR	



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COTTONWOOD CREEK
PALS DESIGN

PROPOSED PLANTING PLAN

DWG. NO.: L-101

CREATED: 11/30/2022

SHEET: 19 of 20

D:\Z\PROJECTS\194-1359-0002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\08_PLANTING PLAN.DWG
PLOT DETAILS: HARVEY, SPENCER November 30, 2022 8:20 PM

CRITERIA FOR PLANTING PLAN
1. LOCAL STOCK OF NATIVE SPECIES SHOULD BE USED TO THE EXTENT POSSIBLE BECAUSE THESE STOCKS WOULD BE BEST SUITED TO AND ADAPTED TO LOCAL CONDITIONS.
2. FINAL PLANTING PLANS WILL BE BASED ON THE FINAL CONSTRUCTION DESIGN. FACTORS SUCH AS TOPOGRAPHY DISTANCE TO STREAM CHANNEL AND SIDE CHANNEL SHALL BE TAKEN INTO ACCOUNT. THE FINAL PLANTING PLAN WILL BE INTENDED TO FACILITATE PLANT SURVIVAL AND TO FACILITATE PROJECT GOAL OF IMPROVING AQUATIC AND RIPARIAN HABITAT.
3. TO AUGMENT SURVIVAL OF RIPARIAN PLANTINGS:
4. FINAL PLACEMENT OF PLANTS SHALL BE CHOSEN BASED ON MICROSITE CONDITIONS, BECAUSE SOIL PROPERTIES AND WATER TABLE DEPTH CAN VARY OVER SHORT DISTANCES, SUCH THAT SPECIES ARE BEST MATCHED TO THEIR SITE CONDITIONS.
5. SITE PREPARATION, SUCH AS REMOVAL OF WEEDS OR OTHER SPECIES THAT WILL COMPETE WITH SEEDLINGS AND TILLING OF THE SOIL SHALL OCCUR PRIOR TO PLANTING.
6. IF NECESSARY, SOIL AMENDMENT, SUCH AS FERTILIZER, SHALL BE INCORPORATED PRIOR TO OR DURING PLANTING.
7. IF NECESSARY, MEASURES SUCH AS TUBING, OR OTHER ANIMAL CONTROL TECHNIQUES, CAN BE UTILIZED TO PROTECT WOODY PLANTS FROM GRAZING/HERBIVORY.
8. IF POSSIBLE, PLANTS SHALL BE INSTALLED IN THE LATE FALL THROUGH EARLY SPRING TO MINIMIZE THE NEED FOR SUPPLEMENTAL WATER AND TO ALLOW FOR THE OPTION OF USING BARE ROOT PLANT STOCK IF AVAILABLE.

GENERAL PLANTING NOTES
1. IF APPLICABLE, SUPPLEMENTAL FERTILIZER MAY BE ADDED TO THE BOTTOM OF EACH TREE AN SHRUB PLANTING HOLE PRIOR TO PLANTING AND BACKFILLING. IF USED,FERTILIZERS SHALL BE SLOW RELEASE PRODUCTS THAT WILL NOT RESULT IN NUTRIENT RUNOFF INTO AQUATIC SYSTEMS.
2. IF APPLICABLE, ADDITION OF MULCH THREE INCHES DEEP MAY BE PLACED IN AN 18 INCH DIAMETER RING AROUND EACH TREE AND SHRUB TO PREVENT COMPETITION WITH INVASIVE SPECIES.

RIPARIAN PLANTING ZONE EXAMPLE SEQUENCE:
1. SEED BARE SOIL AT APPROXIMATELY 30 LBS/ACRE IN SELECTED AREAS AS NEEDED/DESIRED FOR EROSION CONTROL.
2. INSTALL PLANTS BASED ON MICROSITE VARIATIONS WITHIN RIPARIAN PLANTING ZONE.
3. DEPENDING ON DESIRED DENSITY: TREES SHOULD BE PLANTED 10 TO 18 FEET ON CENTER, SHRUBS SHOULD BE PLANTED AT APPROXIMATELY 4 TO 8 FEET ON CENTER. HOWEVER, FINAL PLANT SPACING WILL DEPEND ON SPECIFIC SITE CONDITIONS AND DESIRED OUTCOMES AND SHOULD BE DESIGNED DURING FINAL PLAN DESIGN.

LIVE STAKES DESCRIPTION:
IF USED, LIVE STAKES SHOULD BE INSTALLED ALONG BANKS OF STREAM AND SIDE CHANNEL, WHERE APPLICABLE. THE WIDTH OF THE ZONE FOR PLANTING LIVE STAKES WILL DEPEND ON SITE CONDITIONS AND DESIGN CHARACTERISTICS INCLUDING FINAL GRADE OF BANK AND MOISTURE AVAILABILITY.

EXAMPLE SEQUENCE:
1. SEED BARE SOIL AT APPROXIMATELY 30 LBS/ACRE IN SELECTED AREAS AS NEEDED/DESIRED FOR EROSION CONTROL.
2. INSTALL STAKES BASED ON MICROSITE VARIATIONS WITHIN RIPARIAN PLANTING ZONE.
3. DEPENDING ON DESIRED DENSITY, STAKES MAY BE PLANTED AT APPROXIMATELY 1 TO 10 FEET ON CENTER.

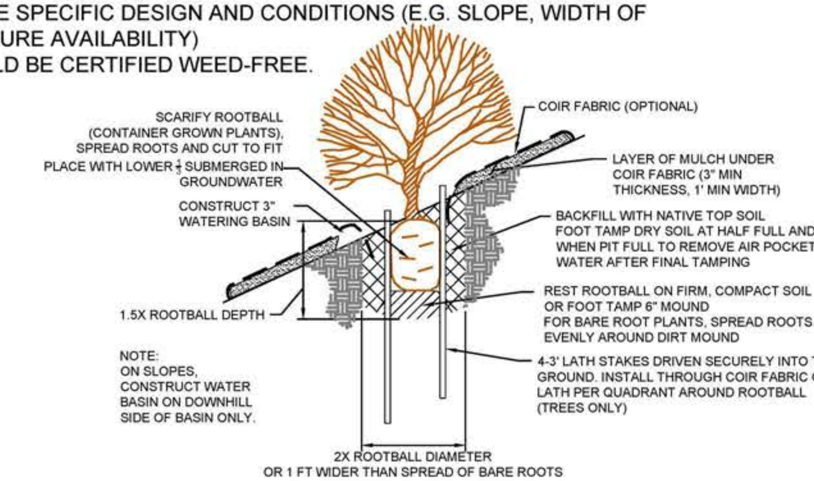
SELECTION AND INSTALLATION NOTES:
1. LIVE STAKES SHOULD BE BETWEEN 18-48 INCHES LONG AND AT LEAST ½" IN DIAMETER.
2. STAKES SHOULD BE CUT STRAIGHT AT THE TIP OF THE BRANCH AND AT AN ANGLE AT THE BASE OF CUTTING TO ENSURE THE CORRECT END IS DRIVEN INTO THE GROUND.
3. KEEP STAKES MOIST AND IN A DARK PLACE UNTIL INSTALLED; DO NOT LET STAKES DRY OUT.
4. SOAKING STAKES BEFORE INSTALLATION INCREASES SURVIVAL AND GROWTH WEIGHT.
5. DRIVE STAKES INTO THE SOIL SO AT LEAST ⅔ OF ITS LENGTH IS UNDERGROUND; LEAVE AT LEAST 12 INCHES ABOVE GROUND.
6. USE THICKER DIAMETER STAKES WHEN PLANTING IN RIPRAP; THICKER DIAMETER STAKES WILL RESIST HEAT AND DRYING BETTER THAN SMALLER CUTTINGS.
7. PLANT STAKES DURING THE DORMANT SEASON.

POTENTIAL SPECIES FOR RIPARIAN SEED MIX		
ACRES: 2.03		
QUANTITY: 60.9 LBS[1]		
SCIENTIFIC NAME	COMMON NAME	PERCENT COMPOSITION
LEYMUS CINEREUS	BASIN WILDRYE	30
FESTUCA IDAHOENSIS	IDAHO FESCUE	20
DESCHAMPSIA CESPITOSA	TUFTED HAIRGRASS	15
ELYMUS GLAUCUS	BLUE WILDRYE	15
PSUEDOROEGNERIA SPICATA	BLUEBUNCH WHEATGRASS	15
BROMUS CARINATUS VAR. MARGINATUS	MOUNTAIN BROME	5
	TOTAL	100

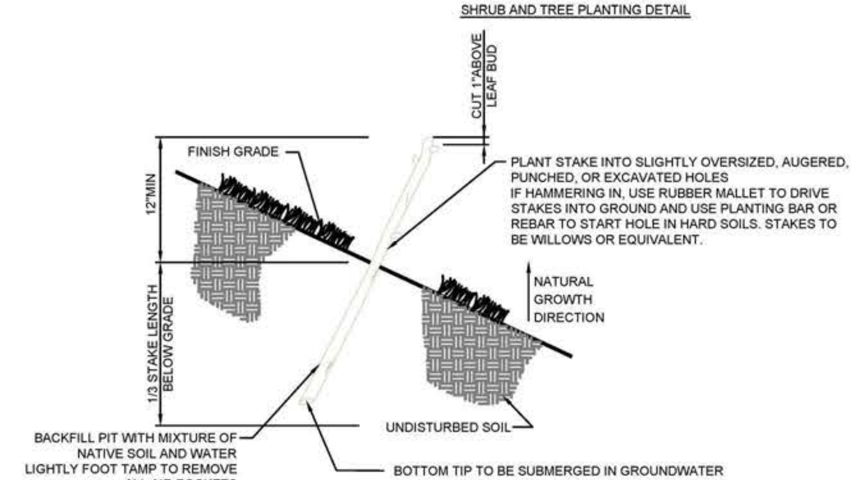
[1] QUANTITY BASED ON 30 LBS SEED/ACRE

SEED MIX DESCRIPTION:
SEED MIX, COMPOSED OF NATIVE SPECIES, SHALL BE USED ON BARE SOIL IN SELECTED AREAS OF THE RIPARIAN PLANTING ZONES AS NEEDED/DESIRED FOR EROSION CONTROL.

NOTES:
1. SPECIES TO BE USED FOR SEED MIX(ES) AND FINAL COMPOSITION SHOULD BE CHOSEN BASED ON SITE SPECIFIC DESIGN AND CONDITIONS (E.G. SLOPE, WIDTH OF PLANTING ZONE, MOISTURE AVAILABILITY)
2. ALL SEED MIXES SHOULD BE CERTIFIED WEED-FREE.



SHRUB AND TREE PLANTING DETAIL



LIVE STAKE PLANTING DETAIL

POTENTIAL SPECIES FOR RIPARIAN VEGETATION							
ACRES: 1.87							
GROWTH HABITAT	SCIENTIFIC NAME	COMMON NAME	PERCENT COMPOSITION[1]	PROPOGATION METHOD	SPACING (FEET O.C.)	DENSITY PER ACRE	QUANTITY
SHRUB	SALIX EXIGUA VAR. EXIGUA[2]	COYOTE WILLOW	20	LIVE STAKES	6	242	453
	CORNUS SERICEA[2]	REDOSIER DOGWOOD	20	LIVE STAKES	6	242	453
	CRATAEGUS DOUGLASSII	BLACK HAWTHORN	10	10-IN PLUG	6	121	226
	PHILADELPHUS LEWISII	LEWIS' MOCK ORANGE	10	10-IN PLUG	6	121	226
	PHYSOCARPUS CAPITATUS[2]	PACIFIC NINEBARK	10	10-IN PLUG	6	121	226
	PRUNUS VIRGINIANA	CHOKECHERRY	10	10-IN PLUG	6	121	226
	SYMPHORICARPOS ALBUS	SNOWBERRY	10	10-IN PLUG	6	121	226
	ACER GLABRUM	ROCKY MOUNTAIN VINE MAPLE	5	10-IN PLUG	6	61	113
	ROSA NUTKANA	NOOTKA ROSE	5	10-IN PLUG	6	61	113
TREES	*ALNUS RHOMBIFOLIA*[2]	WHITE ALDER	50	10-IN PLUG	15	97	181
	POPULUS BALSAMIFERA[2]	BLACK COTTONWOOD	50	10-IN PLUG	15	97	181

[1] PERCENT COMPOSITION ADDS TO 100 FOR EACH STRATA (I.E. TREE, SHRUB)

[2] THIS SPECIES SHOULD BE PLACED NEAR THE BANK OF THE CHANNEL.

TETRA TECH
www.tetratech.com
19803 North Creek Parkway
Bothell, Washington 98011
Phone: 425-482-7600 Fax: 425-482-7652

WALLA WALLA COUNTY CONSERVATION DISTRICT
ESTABLISHED 1941

NOT FOR CONSTRUCTION

PLAN SHEET SIZE ANSI B (11" X 17")

REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK	APP
1	11/30/22	PRELIMINARY DESIGN	SH	AD	JA/CM	CR

COTTONWOOD CREEK PALS DESIGN

PROPOSED PLANTING PLAN

DWG. NO.: L-102

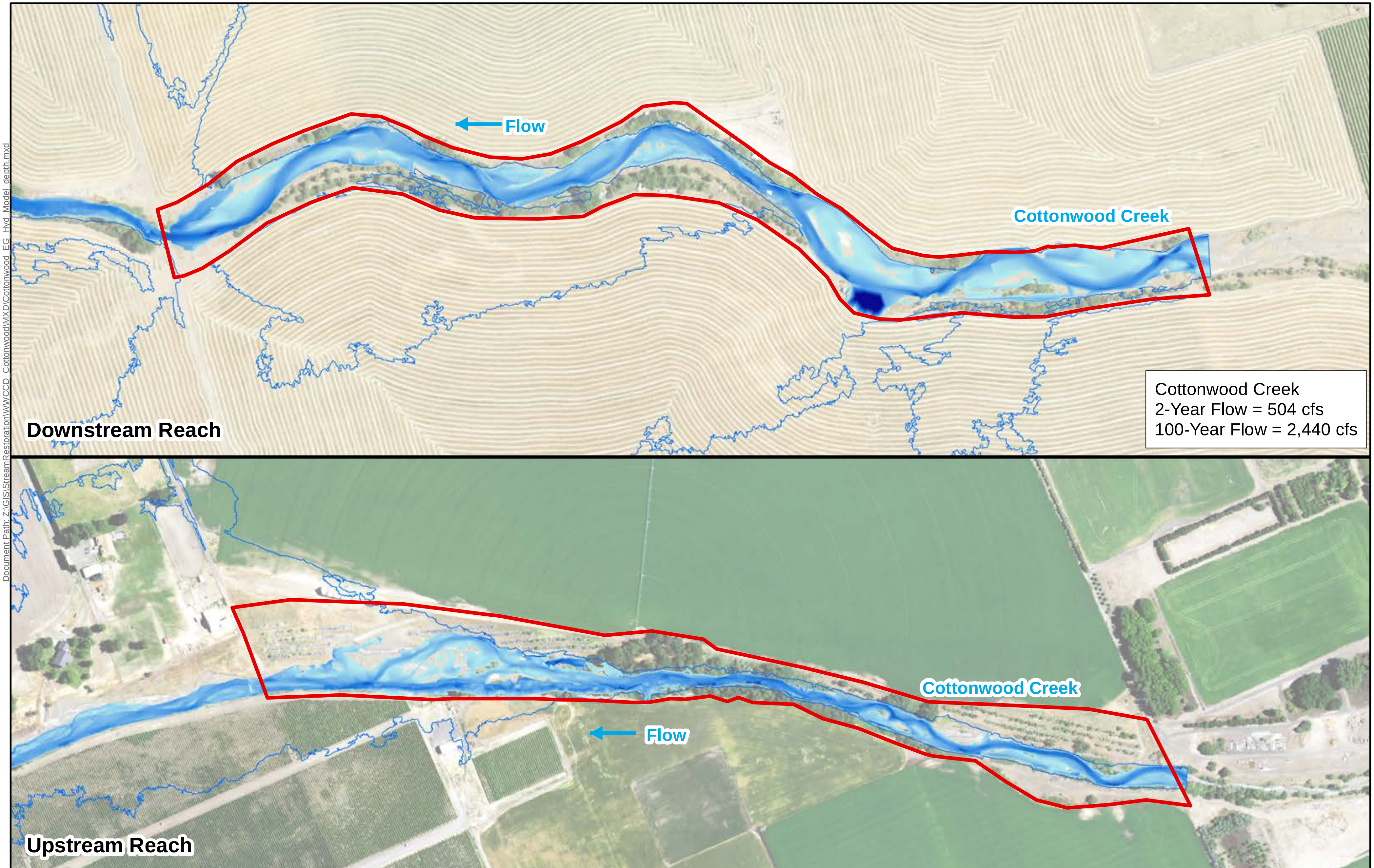
CREATED: 11/30/2022

SHEET: 20 of 20

D:\Z\PROJECTS\194-1359-0002 WWCCD COTTONWOOD CREEK PALS DESIGN\PRELIMINARY DESIGN\SHEET FILES\08_PLANTING PLAN.DWG
PLOT DETAILS: HARVEY, SPENCER November 30, 2022 8:21 PM

APPENDIX C: PRELIMINARY DESIGN ENGINEERING ANALYSES

Hydraulic Modeling Summary
Existing Conditions



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Legend

Inundation Depth (feet)

High : 13.1

Low : 0.0

100-Year Inundation Boundary

Project Area

WALLA WALLA COUNTY CONSERVATION DISTRICT
ESTABLISHED 1941

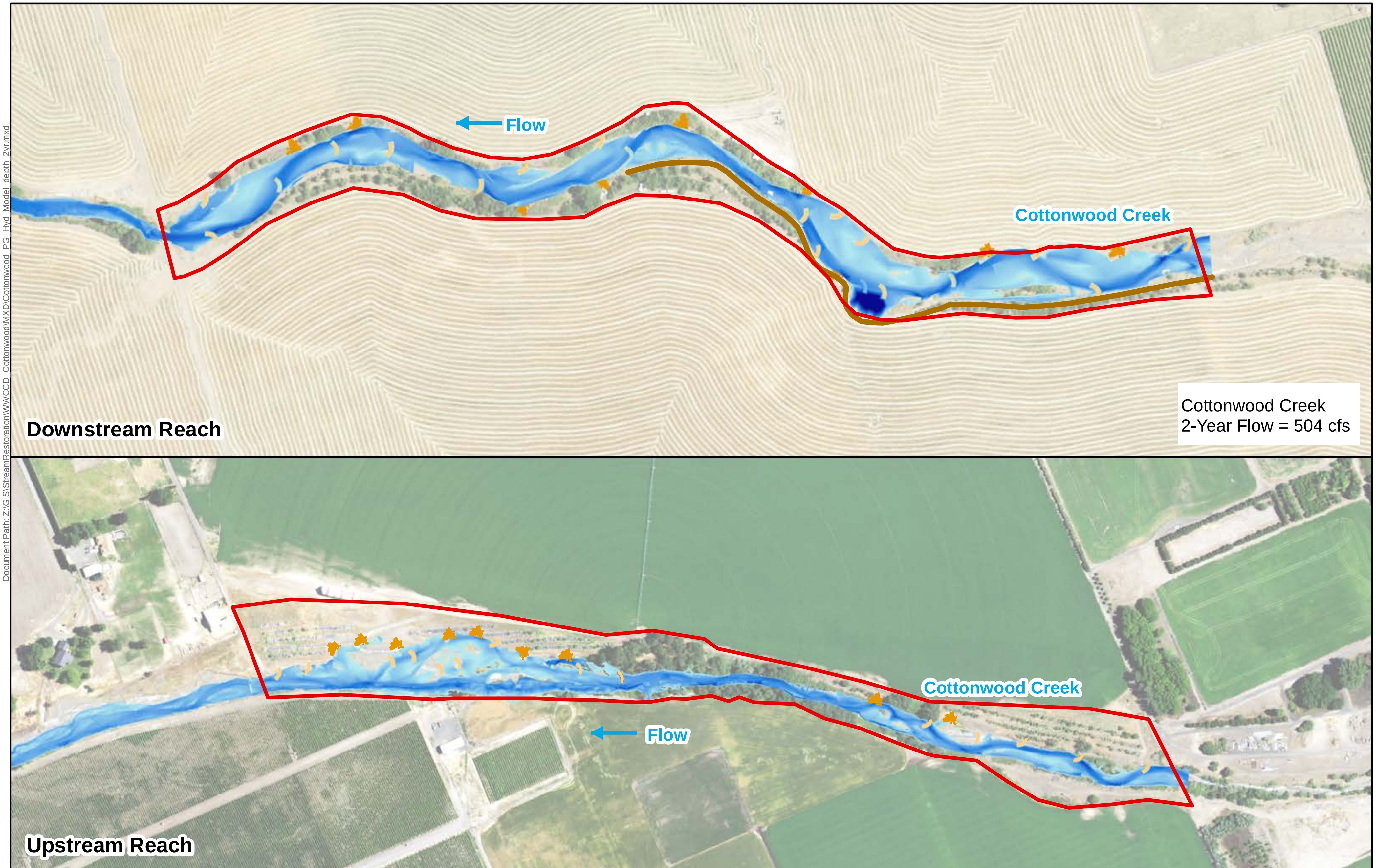
TETRA TECH

Cottonwood Creek PALS Design
Existing Conditions Hydraulic Modeling

N

0 500 1,000
Feet

Hydraulic Modeling Summary
Proposed Conditions



Legend

Inundation Depth (feet)

High : 13.4

Low : 0.0

Project Area

Floodberm

Large Wood Structure

BDA/PALS

WALLA WALLA COUNTY CONSERVATION DISTRICT
ESTABLISHED 1941

TETRA TECH

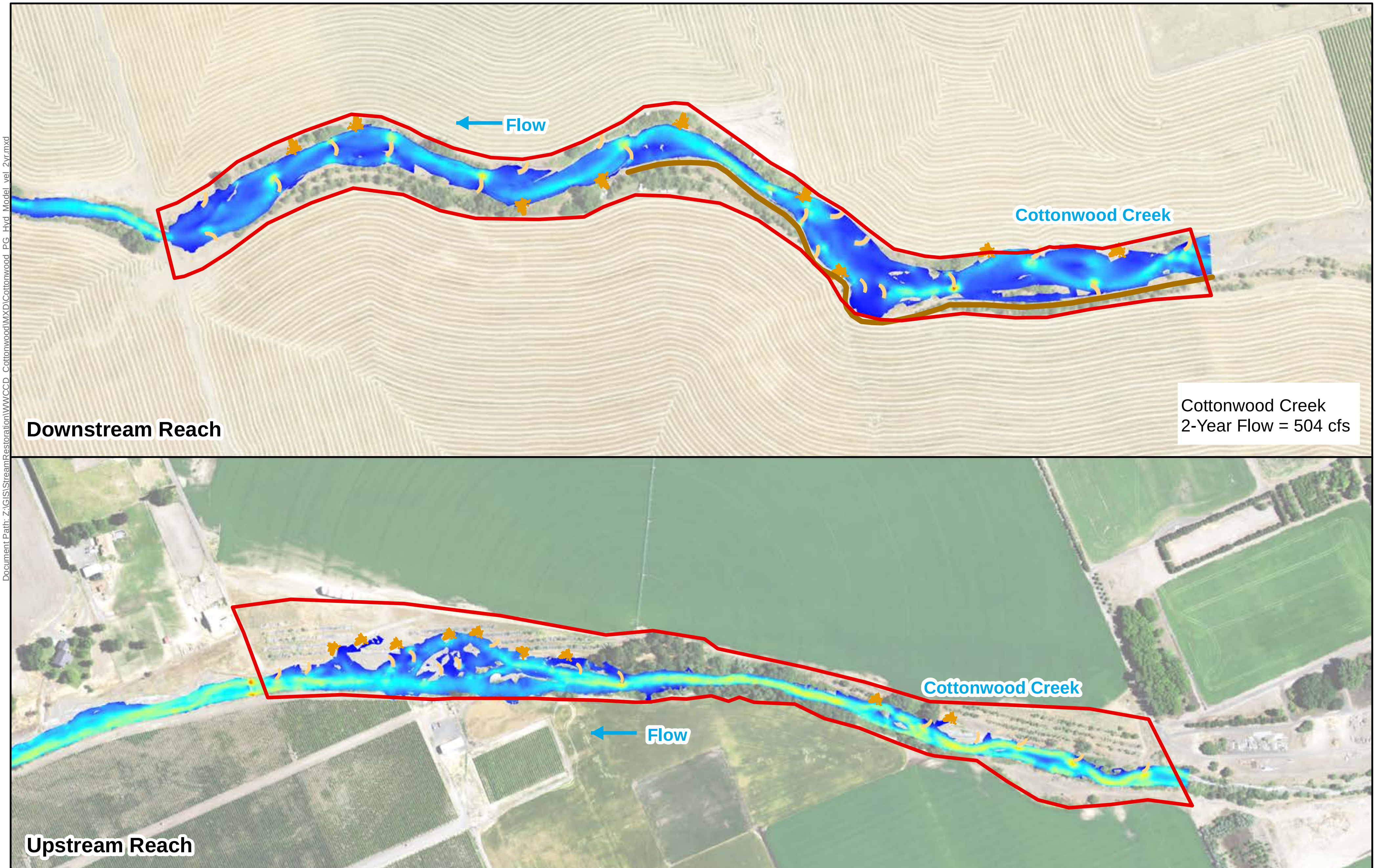
Cottonwood Creek PALS Design

Proposed Conditions Hydraulic Modeling

N

0 500 1,000

Feet



Legend

Velocity (ft/sec)

High : 18.9

Low : 0.0

Project Area

Floodberm

Large Wood Structure

BDA/PALS

WALLA WALLA COUNTY CONSERVATION DISTRICT
ESTABLISHED 1941

TETRA TECH

Cottonwood Creek PALS Design

Proposed Conditions Hydraulic Modeling

N

0 500 1,000
Feet

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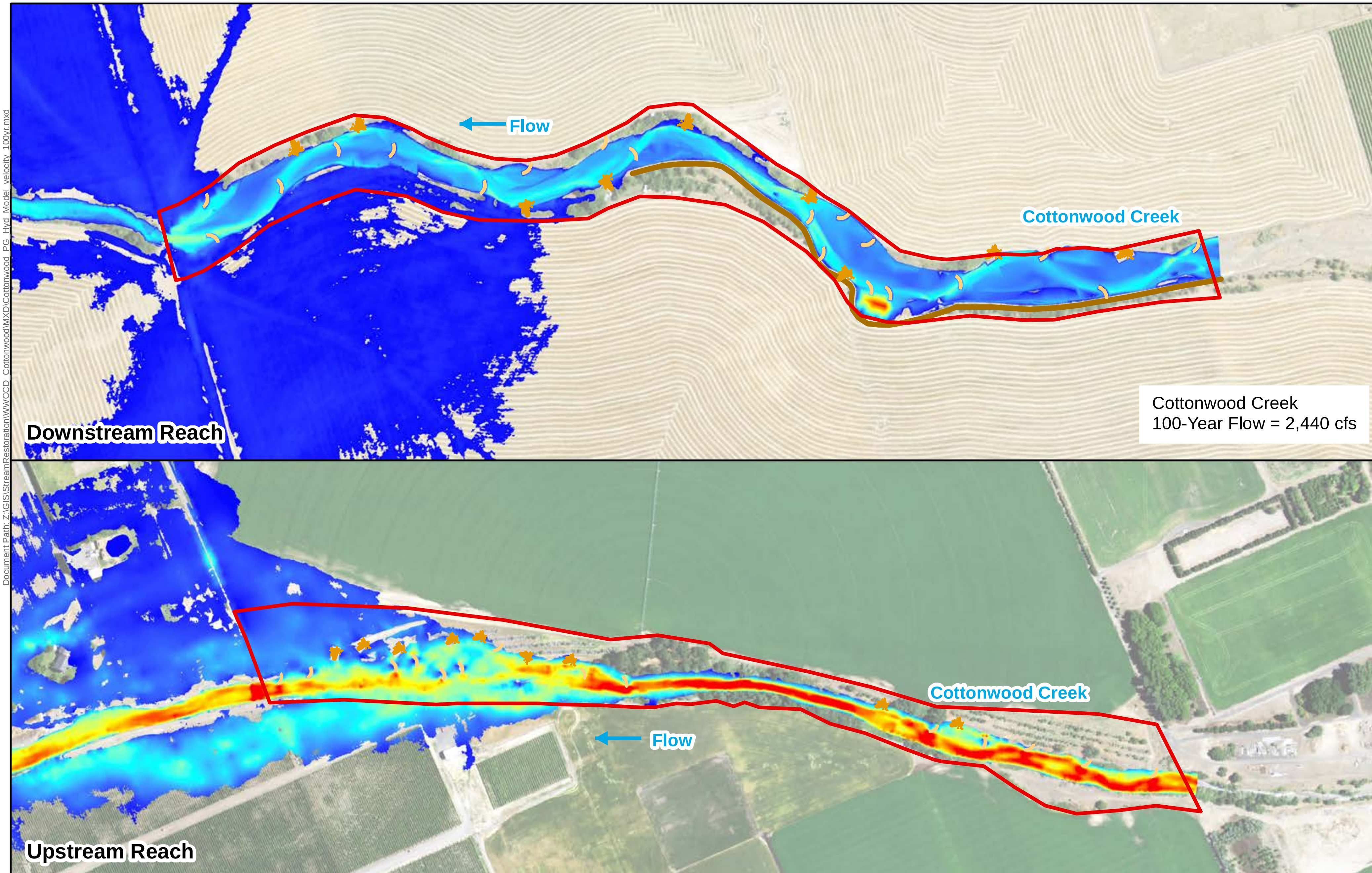


Legend

Velocity (ft/s)

High : 21.7

Low : 0.0

Project Area

Floodberm

Large Wood Structure

BDA/PALS

WALLA WALLA COUNTY CONSERVATION DISTRICT

TETRA TECH

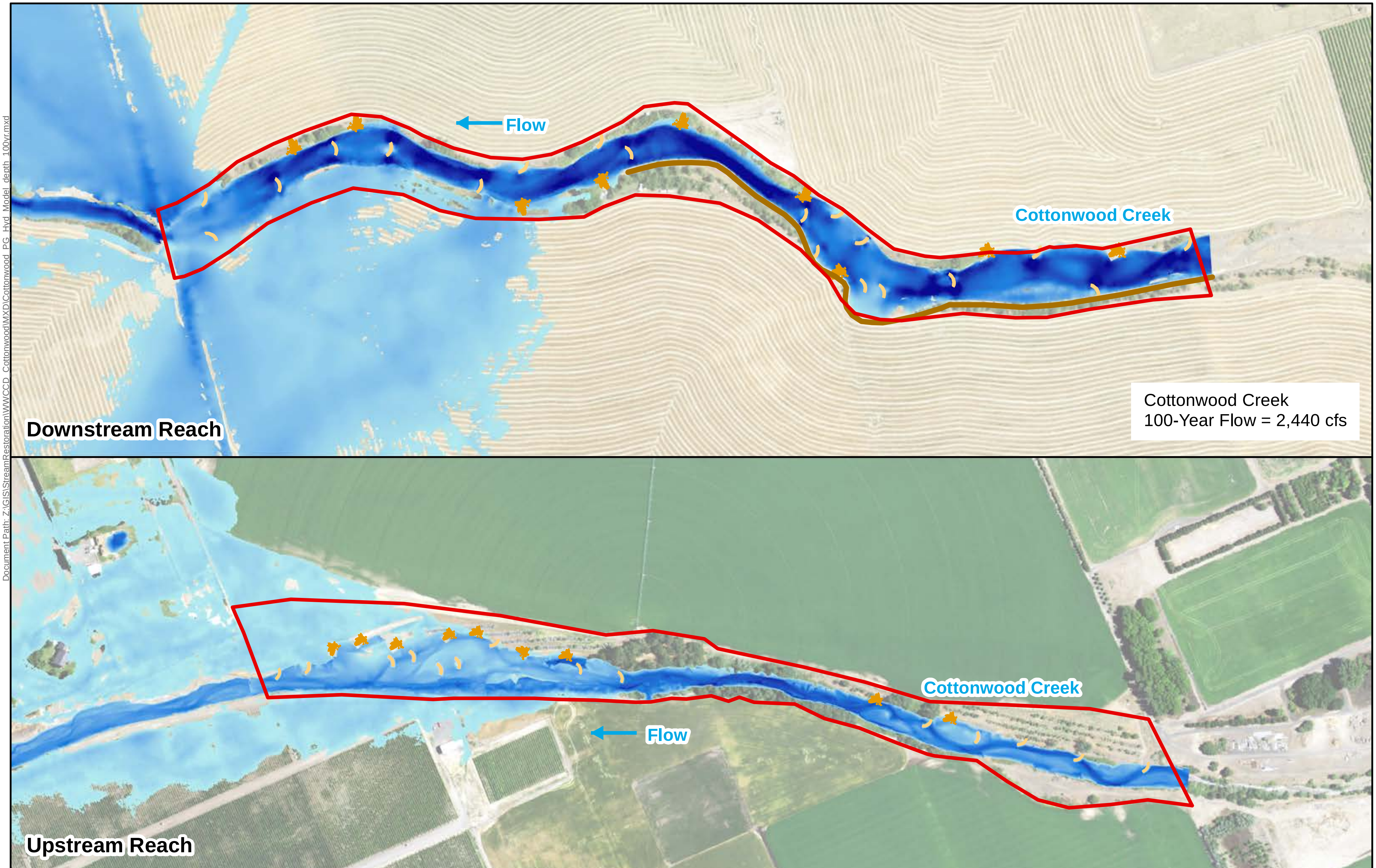
Cottonwood Creek PALS Design

Proposed Conditions Hydraulic Modeling

N

0 500 1,000

Feet



Legend

Inundation Depth (ft)

High : 21.3

Low : 0.0

Project Area

Floodberm

Large Wood Structure

BDA/PALS

WALLA WALLA COUNTY CONSERVATION DISTRICT
ESTABLISHED 1941

TETRA TECH

Cottonwood Creek PALS Design

Proposed Conditions Hydraulic Modeling

N

0 500 1,000

Feet

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Engineering Calculations Summary

Engineered Log Jam Buoyancy Factor of Safety Calculations - Bank Habitat Structure

Methodology based on standard force balance approach, information adapted from D'aoust & Millar (2000), and USBR USACE 2016 National Large Wood Manual.

KEY "BASE" MEMBERS

Number of Logs with Rootwads	N_L =	2				
DOUG-FIR	S_L =	0.40	specific gravity			
Average Rootwad Fan Diameter	D_{RW} =	3	feet	Wood Volume =	65	cubic feet per member
Average Rootwad Length	L_{RW} =	3	feet			
Proportion of Voids in Rootwad	p =	0.2	decimal %			
Tree Stem Average Diameter	D_{TS} =	1.5	feet			
Tree Stem Average Length	L_{TS} =	30	feet	F_{BL} =	4,841	pounds

$$F_{BL} = \left(\frac{\pi D_{TS}^2 L_{TS}}{4} + \frac{\pi D_{RW}^2 L_{RW}}{4} \cdot (1-p) \right) \cdot \rho_w g (1 - S_L) \cdot N_L$$

STACKED "MIDDLE" MEMBERS

Number of Logs with Rootwads	N_L =	2				
pine, ponderosa	S_L =	0.40				
Average Rootwad Fan Diameter	D_{RW} =	3	feet	Wood Volume =	65	cubic feet per member
Average Rootwad Length	L_{RW} =	3	feet			
Proportion of Voids in Rootwad	p =	0.2	decimal %			
Tree Stem Average Diameter	D_{TS} =	1.5	feet			
Tree Stem Average Length	L_{TS} =	30	feet	F_{BL} =	4,841	pounds

$$F_{BL} = \left(\frac{\pi D_{TS}^2 L_{TS}}{4} + \frac{\pi D_{RW}^2 L_{RW}}{4} \cdot (1-p) \right) \cdot \rho_w g (1 - S_L) \cdot N_L$$

TOP MEMBERS

Number of Logs with Rootwads	N_L =	2				
pine, ponderosa	S_L =	0.40				
Average Rootwad Fan Diameter	D_{RW} =	3	feet	Wood Volume =	65	cubic feet per member
Average Rootwad Length	L_{RW} =	3	feet			
Proportion of Voids in Rootwad	p =	0.2	decimal %			
Tree Stem Average Diameter	D_{TS} =	1.5	feet			
Tree Stem Average Length	L_{TS} =	30	feet	F_{BL} =	4,841	pounds

$$F_{BL} = \left(\frac{\pi D_{TS}^2 L_{TS}}{4} + \frac{\pi D_{RW}^2 L_{RW}}{4} \cdot (1-p) \right) \cdot \rho_w g (1 - S_L) \cdot N_L$$

SUBMERGED WEIGHT OF TREES

Base Members	Wt	3,622	lbs
Stacked Middle Members	Wt	3,622	lbs
Key Top Memebers	Wt	3,622	lbs
Total		10,866	(pounds) effective weight for all trees

BOULDER BALLAST

Specific Gravity of Boulders	S_S =	2.66				
equivalent Diameter of Boulder	D_B =	2.0	feet			
Number of Boulders Submerged	N_B =	0				
Number of Boulders above water level	N_{BU} =	0		W' =	434	(pounds) effective weight per submerged boulder
				W =	695	(pounds) weight per boulder
				Total Effective Weight for all Boulders =	0	pounds

$$W' = \frac{\pi D_B^3}{6} \cdot \rho_w g (S_S - 1)$$

BOULDER BALLAST

Specific Gravity of Boulders	S_S =	2.66				
equivalent Diameter of Boulder	D_B =	3.0	feet			
Number of Boulders Submerged	N_B =	0				
Number of Boulders above water level	N_{BU} =	0		W' =	1,465	(pounds) effective weight per submerged boulder
				W =	2,347	(pounds) weight per boulder
				Total Effective Weight for all Boulders =	0	pounds

$$W' = \frac{\pi D_B^3}{6} \cdot \rho_w g (S_S - 1)$$

SOIL BALLAST

Specific Gravity of Soil Particles	S_{soil} =	2.65				
Minimum Soil Dry Density	$\gamma_{d\ min}$=	90	lbs/ft^3			
Maximum Soil Dry Density	$\gamma_{d\ max}$=	115	lbs/ft^3			
Compaction	Dr =	80%	Percent Relative Density			
Unit Weight of Dry Soil Backfill	γ_d=	130	lbs/ft^3			
Void Ratio	e=	0.27				
Porosity	n=	0.21				
Degree of Saturation Below Water Level	S=	100%				
Weight of Pore Water	*w*=	10.26	lbs/ft^3			
Saturated Unit Weight of Soil Backfill	γ_{sat}=	140.26	lbs/ft^3			
Buoyant Unit Weight of Soil Backfill	γ'_b	77.864	lbs/ft^3			
Nominal Footprint Area of Soil Backfill	A_{BF}=	360.0	ft^2			
Depth of Soil Backfill Submerged	Z_B =	2.9	feet			
Depth of Soil Backfill above Water Level	Z_{BU} =	0.0	feet	W' =	52,380	(pounds effective weight per 50 cubic feet of Soil Ballast
Total Volume of Wood	V_d =	388.1	ft^3	W =	0	(pounds) weight per 50 cubic feet of Soil Ballast
				Total Effective Weight for all Soil Lifts =	52,380	pounds

FACTOR OF SAFETY: BUOYANCY

A simplified approach is used to estimate buoyancy where the logs and ballast boulders in the log jam are fully submerged. In addition, the log jam and boulders act as a composite structure and are assumed fully connected. Water velocity inside the log jam is highly turbulent and near zero, therefore vertical uplift forces are assumed negligible.

A minimum factor of safety against buoyancy should be 1.5 with an ideal F.O.S. greater than 2.0.

$$FS_B = \frac{\sum(W + W')}{\sum F_{BL}}$$

FS_B = 4.36

HORIZONTAL FORCES: FRICTION

Bed Sediment Friction Angle	ϕ=	33	Degrees
Bed Stress	μ_{bed}=	0.64940759	
Submerged Weight of Ballast	$W_{bl(sub)}$=	52,380	lbs.
Specific Weight of Water	γw=	62.43	lbs./ft^3
Buoyancy Force	F_b=	14521.7966	lbs.
Drag Coefficient	C_L=	1.5	
Area of Structure Perpendicular to Flow	A=	100	ft^2
Approach Flow Velocity	Uo=	8.2	fps
Gravitational Constant	g=	32.17	ft/s^2
Lift Force	F_L=	9786.58657	lbs.
Normal Force	F_n=	28,072	lbs.
Friction Force	Ff=	18230.0832	lbs.

$$\vec{F}_L = \frac{C_L A \gamma_w U_o^2}{2g}$$

$$\vec{F}_n = W_{bl(sub)} - \vec{F}_b - \vec{F}_L$$

Assumes maximum drag coefficient

Length 20 ft Depth 5 ft

$$\vec{F}_f = \mu_{bed} F_n$$

HORIZONTAL FORCES: DRAG

Drag Coefficient	C_D=	1.5	
Drag Force	F_d=	9786.59	lbs.

Assumes maximum drag coefficient

$$\vec{F}_d = \frac{C_D A \gamma_w U_o^2}{2g}$$

LATERAL RESISTANCE FORCES: VERTICAL PILINGS

Number of Piles	N=	0	
Length of Pile Buried Below Scoured Bed	L_{em}=	0	ft
Pile Diameter	dp=	0	ft
Distance Above Scoured Bed Applied Load	h_{load}=	6	ft
Effective Angle of Internal Friction	ϕ'=	34	Degrees
Rankine Coefficient of Passive Earth Pressure	K_p=	3.53713204	
Horizontal Restraint Force (Pilings)	Fgh=	0	lbs.

$$\boldsymbol{K_p = tan^2\left(45 + \frac{\emptyset'}{2}\right)}$$

$$F_{gh(piles)} = N\left(\frac{\frac{1}{2}L_{em}^3 d_p K_p(\gamma_s - \gamma_w)}{(h_{load} + L_{em})}\right)$$

FACTOR OF SAFETY: SLIDING

Target factor of safety for sliding is 1.75

F_{sh} = 1.86

$$F_{sh} = \frac{\vec{F}_f + \vec{F}_{gh} + \vec{F}_{ah}}{\vec{F}_d}$$

Engineered Log Jam Buoyancy Factor of Safety Calculations - Bank Attached PAL

Methodology based on standard force balance approach, information adapted from D'aoust & Millar (2000), and USBR USACE 2016 National Large Wood Manual.

KEY "BASE" MEMBERS

Number of Logs with Rootwads	N_L =	1				
DOUG-FIR	S_L =	0.40	specific gravity			
Average Rootwad Fan Diameter	D_{RW} =	4	feet	**Wood Volume =**	**95**	cubic feet per member
Average Rootwad Length	L_{RW} =	4	feet			
Proportion of Voids in Rootwad	p =	0.2	decimal %			
Tree Stem Average Diameter	D_{TS} =	1.5	feet			
Tree Stem Average Length	L_{TS} =	35	feet	**F_{BL} =**	**3,555**	pounds

$$F_{BL} = \left(\frac{\pi D_{TS}^2 L_{TS}}{4} + \frac{\pi D_{RW}^2 L_{RW}}{4} \cdot (1-p) \right) \cdot \rho_w g (1-S_L) \cdot N_L$$

STACKED "MIDDLE" MEMBERS

Number of Logs without Rootwads	N_L =	0				
pine, ponderosa	S_L =	0.40				
Average Rootwad Fan Diameter	D_{RW} =	4	feet	**Wood Volume =**	**113**	cubic feet per member
Average Rootwad Length	L_{RW} =	4	feet			
Proportion of Voids in Rootwad	p =	0.2	decimal %			
Tree Stem Average Diameter	D_{TS} =	1.5	feet			
Tree Stem Average Length	L_{TS} =	45	feet	**F_{BL} =**	**0**	pounds

$$F_{BL} = \left(\frac{\pi D_{TS}^2 L_{TS}}{4} + \frac{\pi D_{RW}^2 L_{RW}}{4} \cdot (1-p) \right) \cdot \rho_w g (1-S_L) \cdot N_L$$

TOP MEMBERS

Number of Logs with Rootwads	N_L =	3				
Douglas-fir, coastal	S_L =	0.48				
pine, ponderosa	D_{RW} =	4	feet	**Wood Volume =**	**73**	cubic feet per member
pine, ponderosa	L_{RW} =	4	feet			
pine, ponderosa	p =	0.2	decimal %			
pine, ponderosa	D_{TS} =	1.4	feet			
pine, ponderosa	L_{TS} =	25	feet	**F_{BL} =**	**3,555**	pounds

$$F_{BL} = \left(\frac{\pi D_{TS}^2 L_{TS}}{4} + \frac{\pi D_{RW}^2 L_{RW}}{4} \cdot (1-p) \right) \cdot \rho_w g (1-S_L) \cdot N_L$$

SUBMERGED WEIGHT OF TREES

Base Members	Wt	2,660	lbs
Staked Middle Members	Wt	-	lbs
Key Top Memebers	Wt	6,093	lbs
Total		8,753	(pounds) effective weight for all trees

BOULDER BALLAST

Specific Gravity of Boulders	S_S =	2.66				
equivalent Diameter of Boulder	D_B =	3.0	feet			
Number of Boulders Submerged	N_B =	0				
Number of Boulders above water level	N_{BU} =	0		**W' =**	**1,465**	(pounds) effective weight per submerged boulder
				W =	**2,347**	(pounds) weight per boulder
				Total Effective Weight for all Boulders =	**0**	pounds

$$W' = \frac{\pi D_B^3}{6} \cdot \rho_w g (S_S - 1)$$

BOULDER BALLAST

Specific Gravity of Boulders	S_S =	2.66				
equivalent Diameter of Boulder	D_B =	3.0	feet			
Number of Boulders Submerged	N_B =	0				
Number of Boulders above water level	N_{BU} =	0		**W' =**	**1,465**	(pounds) effective weight per submerged boulder
				W =	**2,347**	(pounds) weight per boulder
				Total Effective Weight for all Boulders =	**0**	pounds

$$W' = \frac{\pi D_B^3}{6} \cdot \rho_w g (S_S - 1)$$

SOIL BALLAST

Specific Gravity of Soil Particles	S_{soil} =	2.65				
Minimum Soil Dry Density	$\gamma_{d\ min}$=	90	lbs/ft^3			
Maximum Soil Dry Density	$\gamma_{d\ max}$=	115	lbs/ft^3			
Compaction	Dr =	90%	Percent Relative Density			
Unit Weight of Dry Soil Backfill	γ_d=	130	lbs/ft^3			
Void Ratio	e=	0.27				
Porosity	n=	0.21				
Degree of Saturation Below Water Level	S=	100%				
Weight of Pore Water	w=	10.26	lbs/ft^3			
Saturated Unit Weight of Soil Backfill	γ_{sat}=	140.26	lbs/ft^3			
Buoyant Unit Weight of Soil Backfill	γ'_b	77.86	lbs/ft^3			
Nominal Footprint Area of Soil Backfill	A_{BF}=	260	ft^2			
Depth of Soil Backfill Submerged	Z_B =	0.50	feet	**W' =**	**20,245**	(pounds effective weight per 50 cubic feet of Soil Ballast
Depth of Soil Backfill above Water Level	Z_{BU} =	0	feet	**W =**	**33,800**	(pounds) weight per 50 cubic feet of Soil Ballast
				Total Effective Weight for all Soil Lifts =	**10,122**	pounds

FACTOR OF SAFETY: BUOYANCY

A simplified approach is used to estimate buoyancy where the logs and ballast boulders in the log jam are fully submerged. In addition, the log jam and boulders act as a composite structure and are assumed fully connected. Water velocity inside the log jam is highly turbulent and near zero, therefore vertical uplift forces are assumed negligible.

A minimum factor of safety against buoyancy should be 1.5 with an ideal F.O.S. greater than 2.0.

$$FS_B = \frac{\sum (W + W')}{\sum F_{BL}}$$

FS_B = 2.65

HORIZONTAL FORCES: FRICTION

Bed Sediment Friction Angle	ϕ=	33	Degrees
Bed Stress	μ_{bed}=	0.649407593	
Submerged Weight of Ballast	$W_{bl(sub)}$=	10,122	lbs.
Specific Weight of Water	γw=	62.43	lbs./ft^3
Buoyancy Force	F_b=	7,110	lbs.
Drag Coefficient	C_L=	1.7	
Area of Structure Perpendicular to Flow	A=	180	ft^2
Approach Flow Velocity	Uo=	11	fps
Gravitational Constant	g=	32.17	ft/s^2
Lift Force	F_L=	35926.84458	lbs.
Normal Force	F_n=	33,800	lbs.
Friction Force	Ff=	21949.97665	lbs.

Length 30 ft Depth 6 ft

$$\vec{F}_L = \frac{C_L A \gamma_w U_o^2}{2g}$$

$$\vec{F}_n = W_{bl(sub)} - \vec{F}_b - \vec{F}_L$$

$$\vec{F}_f = \mu_{bed} F_n$$

HORIZONTAL FORCES: DRAG

Drag Coefficient	C_D=	1.7	
Drag Force	F_d=	35926.84458	lbs.

Assumes structure is not entirely submerged

$$\vec{F}_d = \frac{C_D A \gamma_w U_o^2}{2g}$$

LATERAL RESISTANCE FORCES: VERTICAL PILINGS

Number of Piles	N=	7	
Length of Pile Buried Below Scoured Bed	L_{em}=	8	ft
Pile Diameter	dp=	1	ft
Distance Above Scoured Bed Applied Load	h_{load}=	4	ft
Effective Angle of Internal Friction	ϕ'=	34	Degrees
Rankine Coefficient of Passive Earth Pressure	K_p=	3.5	
Horizontal Restraint Force (Pilings)	Fgh=	41,113	lbs.

$$K_p = tan^2\left(45 + \frac{\emptyset'}{2}\right)$$

$$F_{gh(piles)} = N\left(\frac{\frac{1}{2} L_{em}^3 d_p K_p (\gamma_s - \gamma_w)}{(h_{load} + L_{em})}\right)$$

FACTOR OF SAFETY: SLIDING

Target factor of safety for sliding is 1.75

F_{sh} = 1.76

$$F_{sh} = \frac{\vec{F}_f + \vec{F}_{gh} + \vec{F}_{ah}}{\vec{F}_d}$$

Impact force	Beaver Dam Analog Design		Version 1.0				
PROJECT	Cottonwood Creek					ANALYST	A. Deep	11/15/2022
Structure type	Post line with wicker weave					REVIEWER	J. Andrews	11/15/2022
River and reach	Cottonwood Creek						
Spreadsheet developer	Tetra Tech, Inc.						
Public safety risk	Low						
Property damage risk	Low						
Design discharge	504	cfs	from Hydrology worksheet				
Design discharge return interval	2.0	years	from Hydrology worksheet				
Primary BDA purpose	Improve floodplain connectivity						

		US units/degrees		SI units/radians			
Sediments							
Channel bed sediment		Medium gravel				from Summary worksheet	
Dry unit weight of sediment	γ_{soil} =	120	lbs/ft^3	1,922	kg/m^3	lookup based on sediment type	
Soil friction angle	ϕ =	36	degrees	0.63	radians	lookup based on sediment type	
Sediment specific gravity	S_G =	2.65	-	3.85	-		
Void ratio of soils	e =	0.38	-	3.85	-		
Saturated unit weight of sediment	γ_{sat} =	137	lbs/ft^3	2,197	kg/m^3	lookup based on sediment type	
Rankine passive earth pressure coefficient	K_p =	3.85	-	3.85	-		
Effective buoyant weight of sediment	γ_{eff} =	75	lbs/ft^3	1,197	kg/m^3	lookup based on sediment type	
Horizontal forces acting on posts							
Drag force	F_d =	168	lbs	747	N	from Hydraulics worksheet	
Hydrostatic force on upstream face	F_{hu} =	1,836	lbs	8,164	N	from Hydraulics worksheet	
Hydrostatic force on downstream face	F_{hd} =	-6821	lbs	-30,339	N	from Hydraulics worksheet	
Impact force	F_i =	225	lbs	1,000	N	from Hydraulics worksheet	
Total horizontal force acting on posts	F_t =	-4,593	lbs	-20,428	N		
Number of posts not including bank wraps	N_{posts} =	15	-	67	N	from Structure dimensions worksheet	
Force per post	$\mathbf{F_{post}}$ =	**-306**	**lbs**	**-1,362**	**N**		
Moments acting on posts							
Moment due to drag force		55	ft-lb	74	N m		
Moment due to hydrostatic force on upstream face		17,952	ft-lb	24,344	N m		
Moment due to hydrostatic force on downstream face		-8,164	ft-lb	-11,071	N m		
Moment due to impact force		61,418	ft-lb	83,283	N m		
Sum of overturning moments		71,261	ft-lb	96,630	N m		
Overturning moment per post	$\mathbf{M_{overturning}}$=	**5,090**	**ft-lb**	6,902	N m		
Post rotation failure							
Distance above upstream streambed that resultant load is applied	h_{load} =	3.3	ft	1.01	m		
Downstream flow depth	Y_d =	-0.5	ft	-0.15	m	from Hydraulics worksheet	
Scour depth	h_{scour} =	0.5	ft	0.14	m	from Scour worksheet	
Distance from bottom of scour hole to water surface	$h_{scour} + Y_d$ =	-0.1	ft	-0.02	m		
Minimum post embedment below scour depth	h_{scmin} =	3.9	ft	1.19	m	Based on Broms (1964) equation 8	
Total minimum required embedment	h_{embed_min} =	0.0	ft	1.34	m		
Additional embedment to increase safety factor	h_{add} =		ft	0.00	m	Additional post length to increase safety factor	
Total design embedment	h_{sd} =	5.4	ft	1.65	m		
Height of post above design water surface	h_{above} =	0.3	ft	0.09	m	from Structure dimensions worksheet	
Total length of post	L_{post} =	8.2	ft	2.49	m		
Overturning moment per post	$M_{overturning}$=	5,090	ft-lb	6,902	N m	from Moments section above	
Resisting moment per post	$M_{resisting}$ =	7,787	ft-lb	6,902	N m	Broms (1964) equation 7	
Safety factor for post overturning failure	$\mathbf{S_{Fr}}$ =	**1.53**		1.53			
Minimum safety factor for post overturning failure	$\mathbf{S_{fminr}}$ =	**1.25**		1.25		from Summary worksheet	
Post breakage							
Post diameter, DBH	d_{posts} =	0.5	ft	0.15	m	from Structure dimensions worksheet	
Overturning moment	$M_{overturning}$=	5,090	ft-lb	6,902	N m		
Overturning moment in alternate units	$M_{overturning}$=	61,081	lb-in			in alternate units	
Species of wood used for posts		Pine, lodgepole				from Summary worksheet	
Maximum allowable stress on posts	F_y =	5,900	psi	40.7	Mpa		
Section modulus operating on pile	S_{act} =	8.3	in^3	136	cm^3		
Section modulus at full strength	S_{post} =	21.2	in^3	347	cm^3		
Safety factor for post breakage	$\mathbf{S_{Fb}}$ =	**2.5**		2.5			
Minimum safety factor for post breakage	$\mathbf{S_{fminb}}$ =	**1.25**		1.25		from Summary worksheet	